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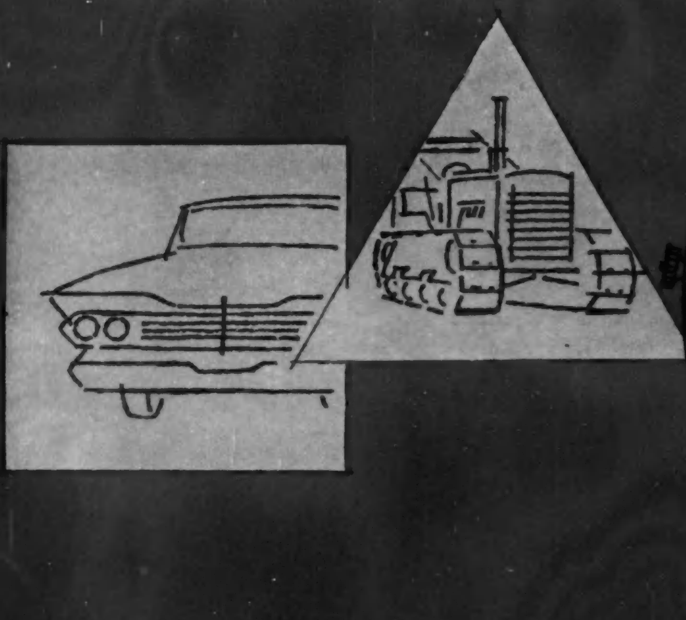
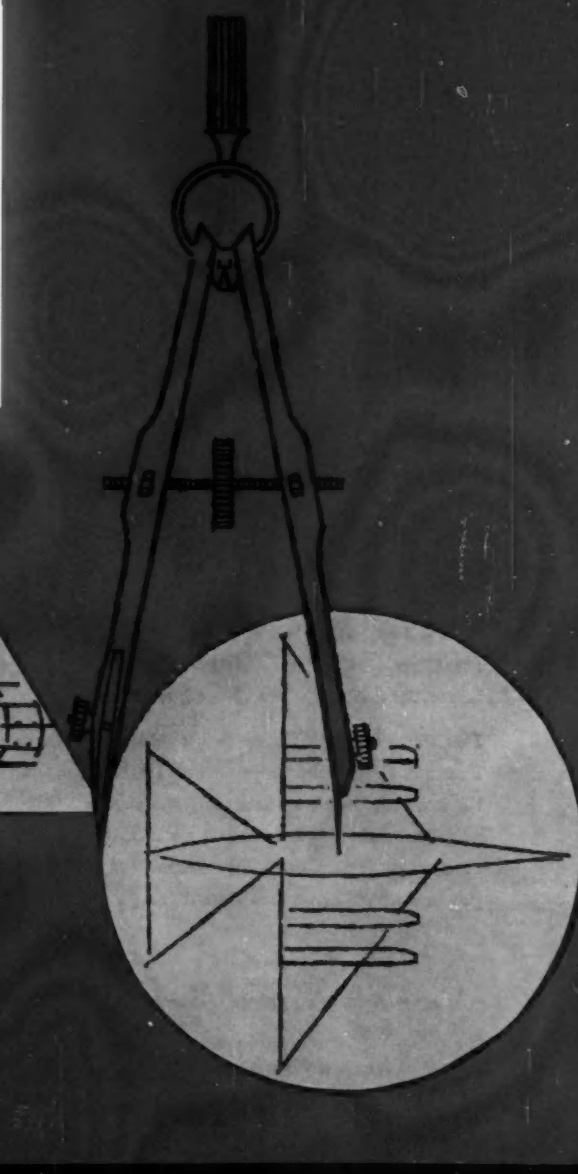
SAE JOURNAL





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Briefs of SAE PAPERS

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To order the SAE papers digested here, circle the numbers in the "Readers Information Service" blank on p. 6 corresponding to the numbers appearing after the titles of the digests of the papers you want.

AEROSPACE

Lockheed BLC Hercules Practical STOL Transport, F. N. DICKERMAN, C. F. BRANSON. Paper No. S259. Development program of large cargo transport, built for U. S. Army and Air Force, included studies of various BLC systems, wind-tunnel program, flight simulator, and flight test program; design objectives were aimed at combining effectiveness of blown flaps with deflected slipstream to reduce take-off and landing speeds and achieve short take-off and landing performance; purpose of boundary layer control is to provide adequate stability and control at low speeds.

Combination Engine Starter and Constant Speed Drive, F. R. CORDON, D. J. HUCKER. Paper No. S268. Problem implied by combining electrical engine starting capability with aircraft generating system; starting characteristics of gas turbine engines are considered and motor performance capabilities of modern aircraft generators; details of hydrostatic transmission evolved by Sundstrand Aviation and discussion of electrical system and controls associated with such system.

Systems Engineering Considerations in Designing and Testing Life Support System for Project Mercury, J. R. BARTON. Paper No. 245B. Objectives of NASA's project to investigate man's performance capabilities in space and recover man and capsule; specifications developed for all systems of vehicle to insure compatibility of functions between occupant, vehicle and mission requirements; determination of methods of accomplishing necessary system functions to maintain suit pressure, provide breathing oxygen, remove heat, CO_2 and moisture; schematic of system, method of operation.

Scheduling and Dispatching for Airline Aircraft, T. M. PLUNKETT. Paper No. S256. Scheduling is basis for determining utilization of flight, ground equipment and employees at United Airlines; decisions made by policy committee include level of service, new or changed service in specific areas, fleet composition, special projects, overhauls, etc.; problems of scheduling relating to equipment, crews, route and airport factors, traffic requirements, etc; functions of operations planning center and flight dispatch organization; method for jet operation using computer.

Status of GEM Developments, M. F. SOUTHCOTE. Paper No. 270A. Survey of GEM, ground effect machine, or air-cushion vehicle relating to some concepts, acomplishments, and problems which must be solved; lifting power requirements of annular jet concept are defined and effects of geometry on power requirements; propulsion, stability, and control aspects; two design studies are used in operational analysis which compares air-cushion vehicle operating costs with those of existing transport media.

Marine Air Cushion Vehicles — Operational Limitations and Future Developments, P. G. FIELDING. Paper No. 270B. Comparisons of over-water GEM with other marine vehicles are made and some of major problem areas associated with over-water operation highlighted; review of current hardware and designs; description and illustrations of marine types for commercial and military operations; indication of size and speed range capability of each type given.

GEM for Amphibious Support, J. L. WOSSER, A. J. VAN TUYL. Paper No. 270D. Design study for Amphibious Support GEM shows how best to achieve optimum performance once military requirements for such vehicle are developed; considerations of various alternatives and compromises that might be necessary are pointed out; final design figures and performances

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TEAR ALONG PERFORATION

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and design parameters used; summary of government sponsored research work in progress in tabular form and by task description.

FUELS AND LUBRICANTS

Does MS Test Predict Field Performance? C. C. COLYER, T. B. TOM. Paper No. 262A. Automobile makers jointly developed laboratory engine-test procedures for appraising motor oils blended for API Service Classification MS; 12 oils run in 40 vehicles for total of 2 million mi were evaluated; because different engines responded differently to identical oils, laboratory test could not be expected to correlate with all field results; it is concluded that MS Test satisfactorily supplants several engine tests used, but it is not broad enough to cover all aspects.

Motor Oil Evaluation: Laboratory Engine Tests for MS Service and Field Performance, A. E. BRENNEMAN, D. R. HARSELL, N. R. ROUX, G. K. VICK. Paper No. 262B. Paper discusses relation of "MS tests" to passenger car performance with regard to sludge and varnish deposits; MS laboratory engine test results are first compared with those of taxicab field test; deposit levels in taxis are then shown to be typical of those found in actual passenger car operation.

Some Problems With Determination of Used Oil Insolubles And Their Relation to Engine Cleanliness, P. A. ASSEFF, R. K. WILLIAMS. Paper No. 262C. Technique for insolubles determination in used crankcase oils can seriously limit confidence placed in such information as related to engine condition or mechanism by which oil additives perform various functions; results of programs carried out by Lubrizol Corp. toward better understanding of engine cleanliness and used oil condition; determination of coagulated oil insolubles by filtration using Gooch crucible.

Combustion Characteristics of Compression Ignition Engine Fuel Components, D. R. OLSON, N. T. MECKEL, R. D. QUILLIAN, JR. Paper No. 263A. Study made at Ordnance Fuels and Lubricants Research Laboratory; CFR and CLR diesel engines were used and multicylinder verification of data obtained with GM 3-71 engine; results obtained with 50 pure hydrocarbons show importance of molecular structure on compression ignition combustion; cetane number was most important property for predicting relative combustion performance of all fuel components; other findings.

Effect of Variables on Caterpillar L-1 Test, J. J. LORZING, JR., H. B. ANDERSON. Paper No. 263B. Diesel engine oil test used for determining detergency characteristics of lubricating oils; usefulness of test seems severely limited by relatively poor reproducibility; investigation deals with this facet of test; it is shown that number of uncontrolled variables such as oil consumption rate and injector needle lift variations significantly affect test results; intake air temperature and humidity seem to have lesser effect.

Save Time in Formulating Diesel Lubricants, H. E. DEEN, A. A. SCHETELICH. Paper No. 263C. Details of Enjay engine test used to evaluate performance of lubricants in internal combustion engines; test predicts Caterpillar L-1 test performance of lubricants under MIL-L-2104A or MIL-L-2104A Supp I test conditions; data and correlations developed frmo test results are presented; test is particularly useful in evaluating diesel performance of experimental additives and additives components; summary of advantages.

Motorist Looks at Winter Performance, C. S. GILBERT, JR., E. F. MARSHALL. Paper No. 264A. Mail questionnaire survey of motorist reaction, made by Sun Oil Co., was designed to provide data on starting, warmup, and stalling difficulties; make of car involved; brands and grade of gasoline used; opinion as to whether brand of gasoline is factor, and if so, which brands give best and which poor performance; it is concluded that winter performance problems exist to signifi-

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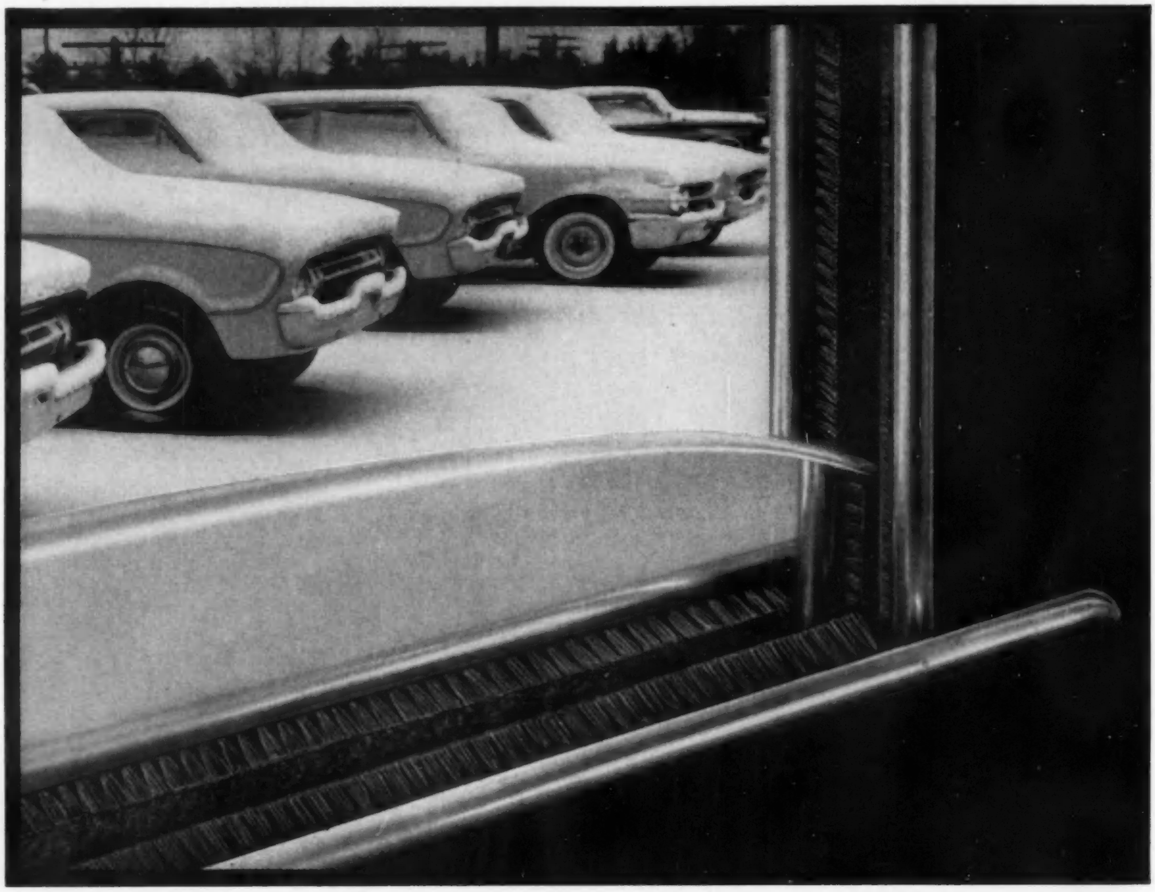

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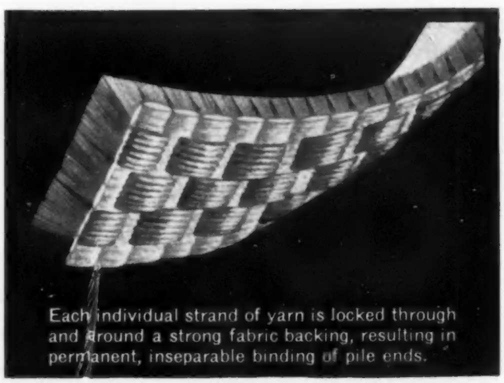

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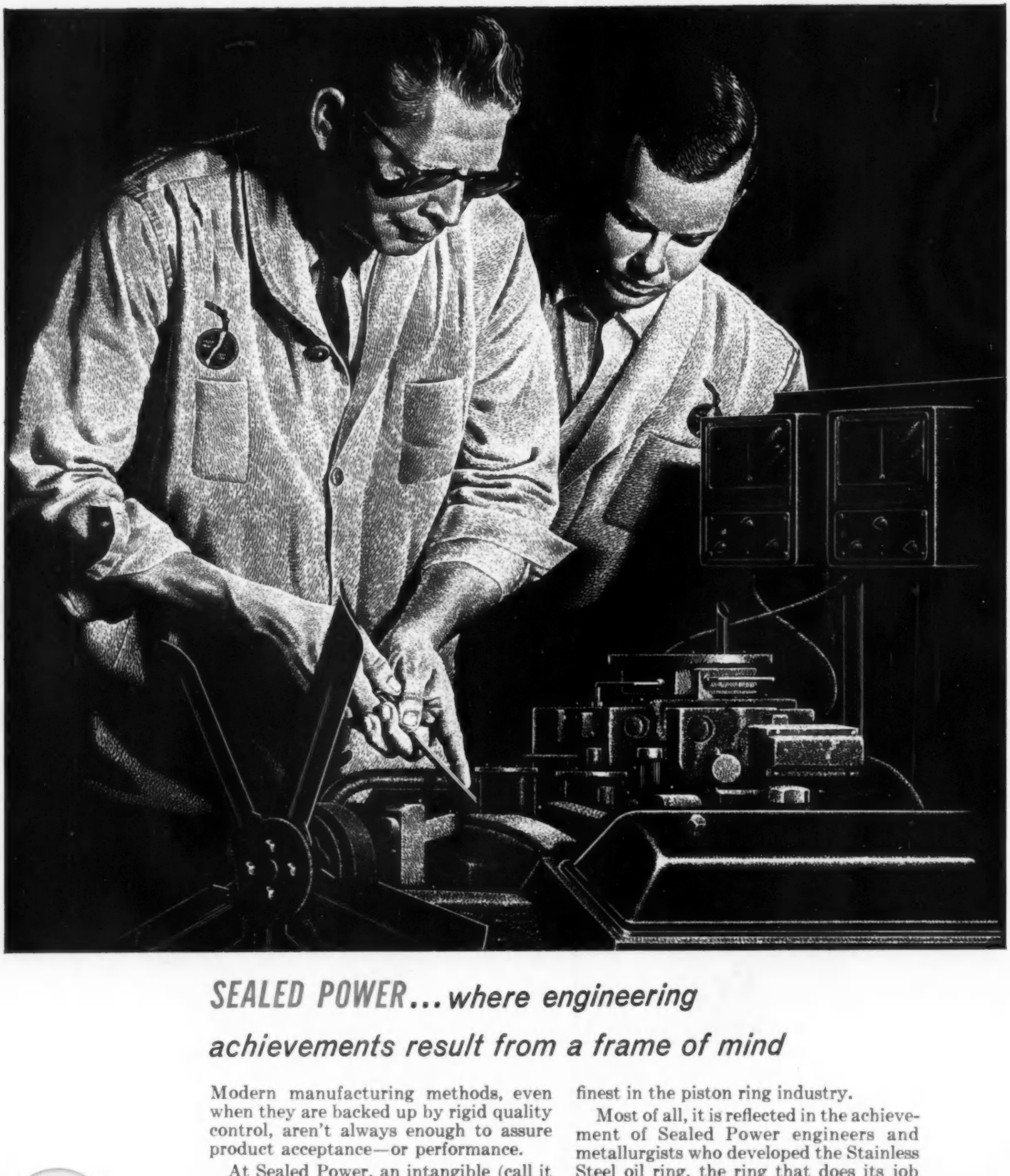

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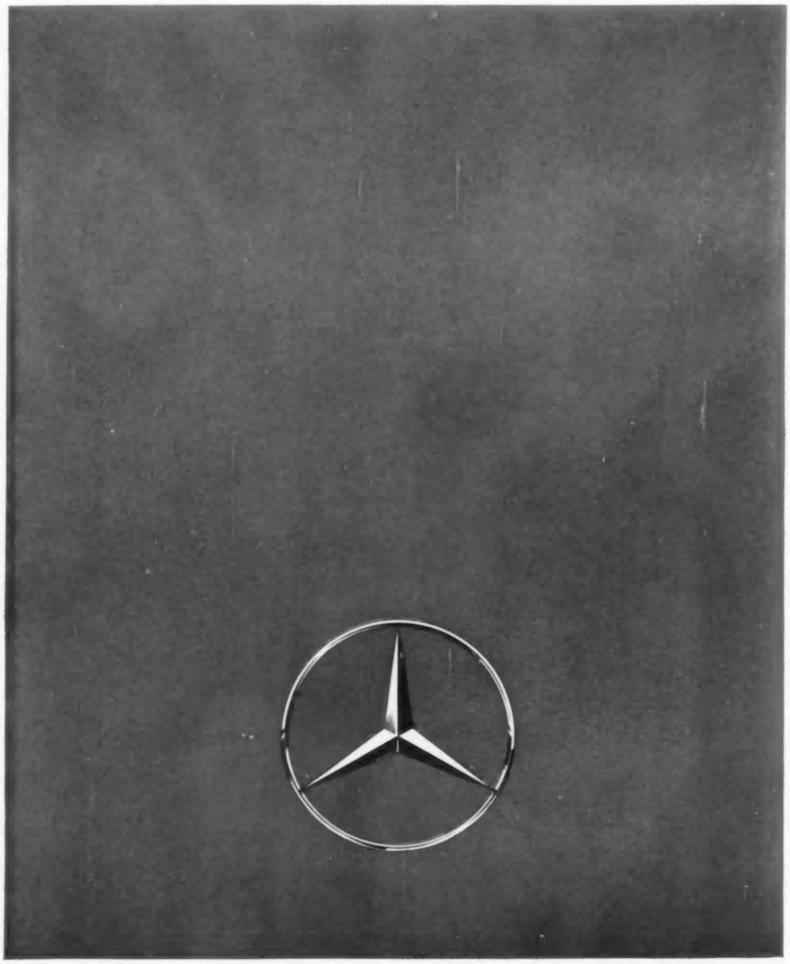

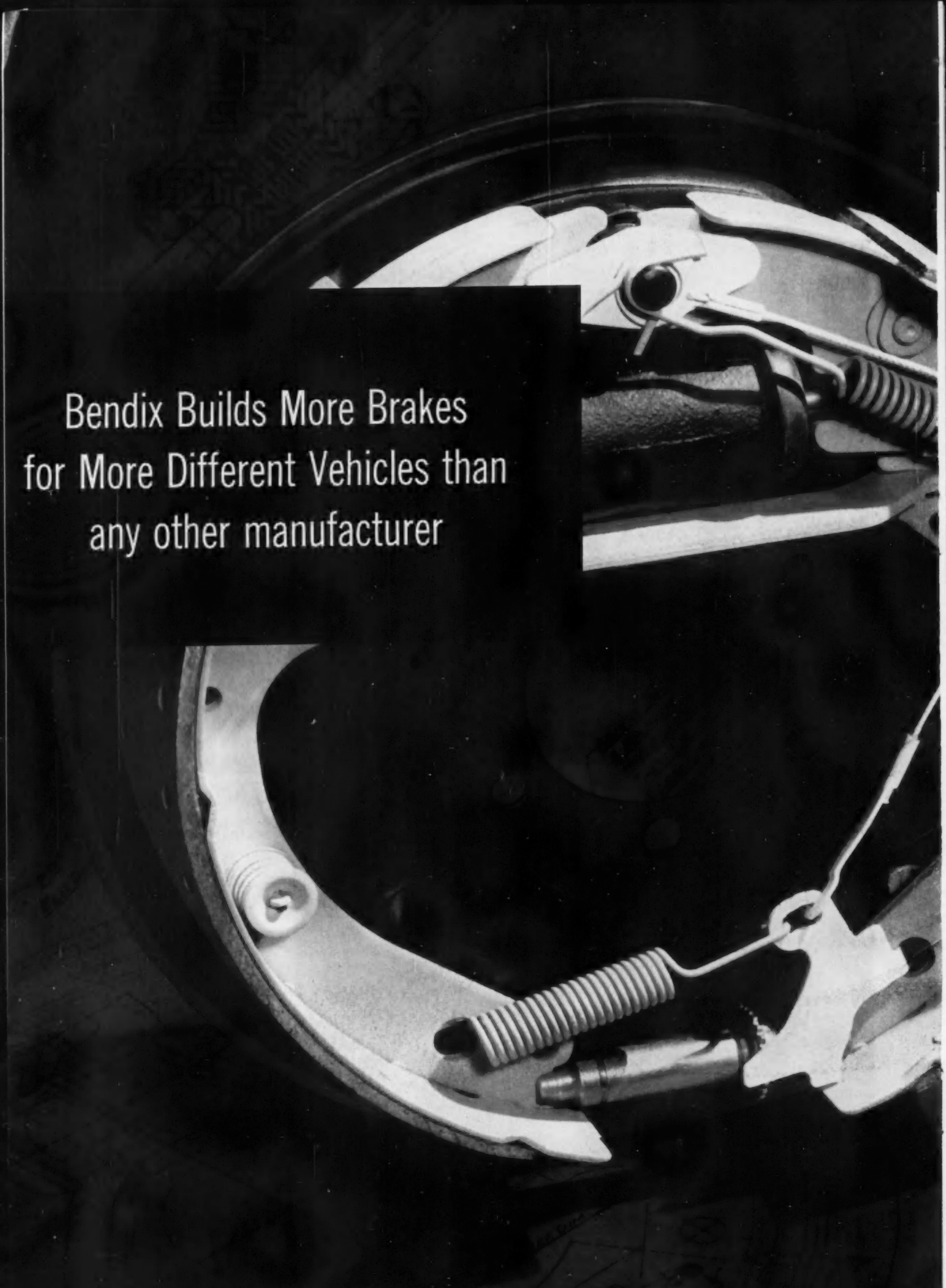
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For Sake of Argument

GROWING UP . . .

MOST OF US grow up intellectually years before we mature emotionally. We reason and act quite objectively in many areas of business life, but still react childishly when emotions get involved.

Then, we are apt to school, control, or direct our emotions to conform with what our intellect tells us objectively is true. But we fail to get from a control process results which require emotional adjustment. Our controls may even make matters worse until experience reveals their weakness.

Finally, we decide, there is no substitute for actually growing up emotionally . . . no substitute for "seeing" and feeling — as well as just thinking — objectively. So, we begin to adjust . . . always to see ourselves as individuals revolving in an environment of other individuals. We recall that the universe made better sense to astronomers once they recognized the Sun — not Earth — as the center point. Our world makes better sense to us when we don't think of ourselves as the point about which our environment rotates.

To view clearly any event, we need a habit of "feeling" it from others' viewpoints, as well as just seeing it that way with our intellect. . . .

We need a habit of wanting more to move *toward* something good than to *resist* something bad. We need a habit of reacting in terms of principles rather than persons.

When such responses become habitual, they help greatly toward 20–20 vision for the mind's eye and maturity for emotional life.

Norman G. Shidle

chips

from SAE meetings, members, and committees

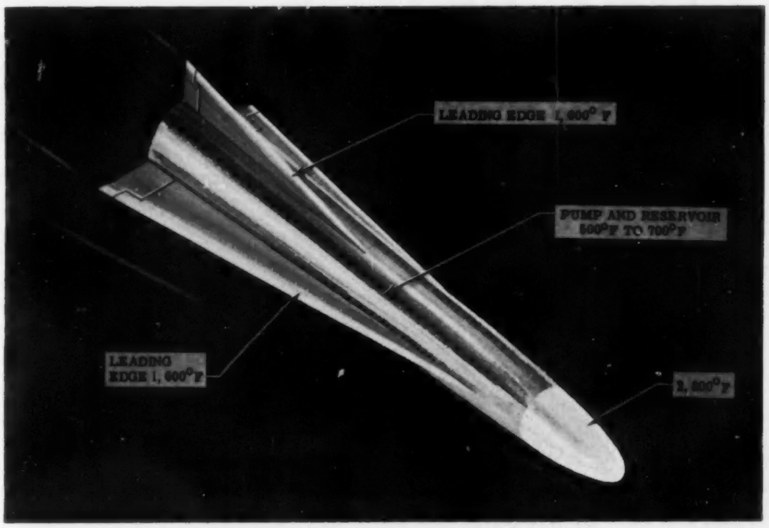
THE MOST PRESSING SINGLE PROBLEM in converting liquid propellants to gases for pneumatic control systems lies in the development of a gas generator with a large flow range capacity — on the order of 1000 to 1.

TO FACILITATE STANDARDIZATION within the North Atlantic Treaty Organization (NATO) some years ago, a U. S. Army regulation initiated conversion of U. S. Army weapons and related equipment to use of the meter for measurement of linear distances. (The aim also was to permit better and more extensive use of allied and captured enemy materials and to simplify procedures for indirect firing of weapons.) . . . Eight years were needed to complete the conversion — on this relatively small segment of defense activity.

PER-CAR CONSUMPTION OF PLASTICS, in relation to the weight of the car, is higher in European cars than in U. S. cars. For example, on a weight adjusted basis, the 1959 Volkswagen was using about 60 lb of plastics per car, Fiat 26 lb, and the average U. S. car 20 lb.

NASA's Lewis Research Center in Cleveland has permitted qualified staff members to assume part-time teaching responsibilities at Case Institute of Technology and other local colleges for more than 15 years . . . to teach courses related to aerospace propulsion problems. It has also provided these colleges with outlines and lecture notes of some of these courses and of some Lewis' internal courses, which the college faculties used in teaching the same subjects. Aim: to help the colleges provide the trained engineers and scientists necessary to keep pace with advancing technology . . . a difficult task in view of the rapid developments in science.

AVERAGE USE OF PLASTICS will increase from an estimated 25–30 lb used in today's cars to 50 lb or more by 1970, according to recently published estimates made by technical representatives of Du Pont. Studies show the average use of plastics in cars jumped from 10 lb in 1954 to 25 lb in 1959 models.



TEMPERATURE DIFFERENCE between the upper and lower faces of re-entry vehicle control surfaces may be as high as 1100 F. The lower portion and leading edge of the control surface reach 1600 F, while the upper face might only be 500 F, during re-entry. Expected nose temperatures are in the vicinity of 2800 F.

25,000

Break ALL SAE Records!

See report of 1961 SAE International Congress and Exposition of Automotive Engineering . . . p. 101

This is a front view of the 1970 "UTOPIA," a car of the future. Note the absence of the A pillars providing an unobstructed view for the driver. Also evident is the horizontal "light bar" replacing today's conventional headlights. The car has a 110 in. wheelbase and is powered by a fuel cell.

Fuel cell car

. . . calls for extensive redesign

Based on paper by

Brooks Stevens

Brooks Stevens Associates

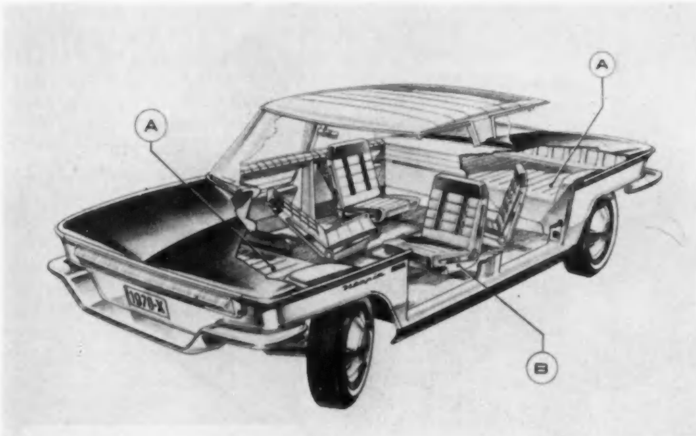
THE AUTOMOBILE OF TOMORROW may base its design on a desirable wheel tread and wheelbase for six passengers (family sedan) or nine passengers (station wagon). Frame construction and unit construction are both applicable to this concept. New materials and their fabrication need not be based on present-day realities; lightweight materials, plastics — both transparent and opaque — will combine with equally advanced interior materials for seating and trim. This all will be possible in a breakthrough approach to the fuel cell automobile.

FUEL CELL ENERGY can conceivably revolutionize personal transportation on the highways by 1970.

In this article, Brooks Stevens, renowned industrial designer, assumes a practical fuel-cell powerplant contained within the confines of the body shell and discusses the effect such an "engine" may have on future automobile design.

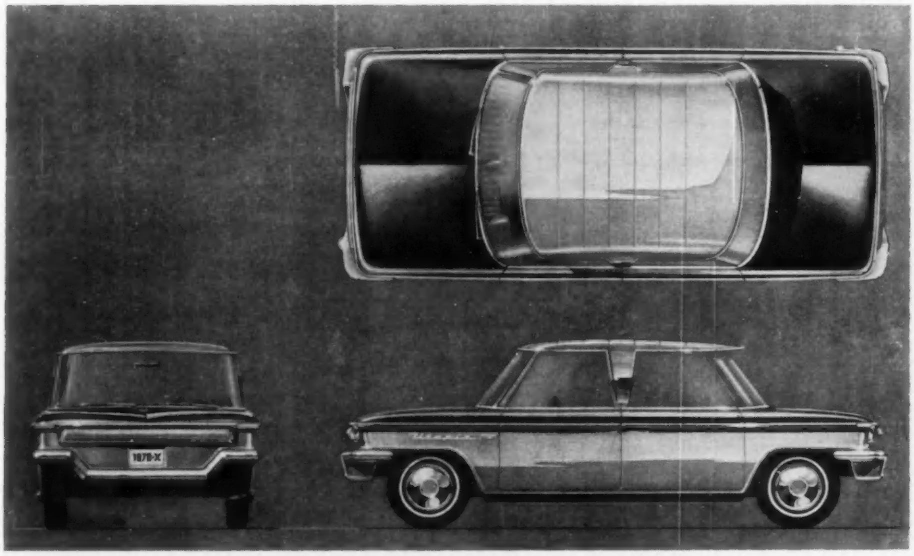
I envision this car for the mass transortation market to be a not too compact Compact — 110 in. of wheelbase without the requirements of long frontal engine compartments and equally elongated rear deck will allow for a symmetry of form that can conceivably bring the initial tooling investment down to a refreshingly low minimum. In envisioning this car — which I shall facetiously call "Utopia" — I will concede all former styling motifs which attempted to denote a front and a rear, a hood and a tail, a borrowing on the directional look of an airplane or a rocket. I predict that the passenger carrying tonneau will be an orderly bin of comfortable dimensions with a completely flat floor pan allowing for six individual and individually operated bucket seats — these seats to be orthopedically comfortable and have passenger stability in themselves. They can be adjusted individually in all directions and can be individually reclining. Six bucket seats sliding on a uniform decorative floor surface will allow for different sized members of a passenger group to adjust their own comfort.

The seat mountings in the symmetrically flat floor can be arranged as in commercial aircraft of today with the ability to relocate and even eliminate the two center seats if desired. This would allow for the remaining passenger seats to be swiveled in any direction.



This cut-away view of the "UTOPIA" shows the flexible seating arrangement and large luggage compartments. The seats can be moved to any position or even eliminated, if desired.

A — Luggage compartments
B — Fully adjustable bucket seats can be relocated anywhere in car even eliminated



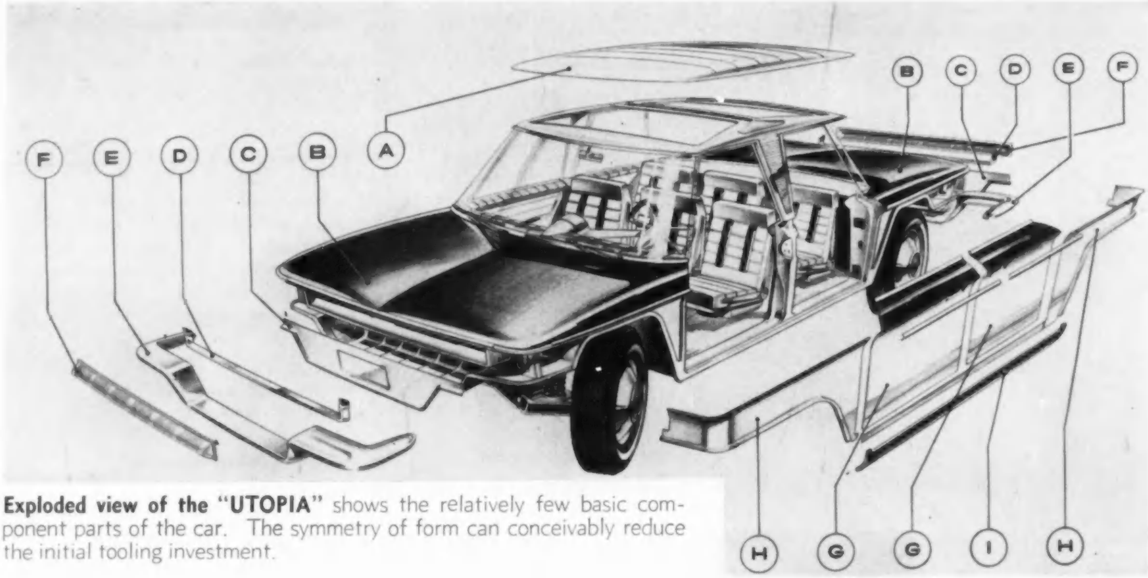
Three-view scale drawing of the 1970 "UTOPIA."

It is entirely possible that sealed seat cushions will contain high viscosity silicon fluid to dampen out any vibration. The fluid will allow the cushion to mold to the contour of the passenger supporting with low uniform pressure over the entire body surface. Springs and airfoam will be forgotten and archaic in the orthopedic seating of tomorrow's car.

Beginning, then, with this centrally and symmetrically located passenger arrangement on independently sprung wheels within an optimum wheelbase I will begin to build a comfortable enclosure. The short functional quarter panels can be used fore and aft as identical stampings, or moldings, or diecastings — whichever may be the order of the day — in steel, aluminum, magnesium, fibreglass, or a yet unknown moldable material. Four doors mounted symmetrically between the wheelhouses, without wheelhouse cutouts, can be transferred in the manufactured element from front to rear and from left to right. These doors will not be as thick as we know them today in deference to the amphibious style. They will have sculptured rigidity built into their form and the extreme dimension of this car will not greatly exceed the outside of the tire line.

In addition, a single bumper design and part will be used front and rear — this of a resilient material impervious to shock and wear. Rocker panels of a resilient or a rubber-like plastic will provide curb rub rails and eliminate the unsightly rusting out of the sheet metal of today.

A centrally located *B*-pillar, also symmetrical in design fore and aft and right and left, will support in cantilevered fashion a roof shape. The front windshield will be utilized in counterpart as the rear window. No *A* pillars, or *C* pillars, will exist. Glass or plastic side windows will underlie the windshield proper and the windshield itself will be a



Exploded view of the "UTOPIA" shows the relatively few basic component parts of the car. The symmetry of form can conceivably reduce the initial tooling investment.

A — Cantilevered roof

B — Front and rear covers — identical stampings

C — End panels — identical stampings

D — Light bezels — identical front and rear

E — Bumpers — identical front and rear

F — Light lens — identical front (clear) — rear (red)

G — Door panels — identical stamping for all doors

H — Quarter panels — left front/right rear identical right front/left rear identical

I — Rocker panel — Rubber-like plastic

This rear view of the "UTOPIA" shows it as a nine-place utility station sedan. It has a sliding telescopic roof providing either an exposure to the sun or the ability to load this area as a pickup truck.

"UTOPIA"

. . . continued

portion of supporting strength for the roof panel. The absence of *A* pillars and the improved vision gained will not require the alleged benefits of wrap-around windshields making door entry and exit difficult and ungraceful. It is entirely possible that the overall height of this car will be increased from what we know today because we will not be slaves to the low slung forward look. Interior head room and comfort will improve and increase proportionately with again the reference, perhaps, to chair height seats.

A frontal luggage area cover will be so designed as to act in symmetrical fashion as the rear luggage area cover. The basic differential beneath will be the wheelhouse clearances for steering the front wheels. The resulting dual luggage area allows for infinitely less overhang at both ends of the vehicle and therefore a more compact and maneuverable mass.

The designer will no longer have the dual headlight problem of whether to be horizontal, vertical, or angular in placement. A simple horizontal bar of light from a translucent plastic airfoil section will reach across the car terminating at each simplified corner in directional and parking or braking lights. This same element will be reused across the rear

of the vehicle pigmented in red for the required warning light effect. The instrument panel of this car will be a centrally located pod at cowl level containing a minimum of instruments. How fast and how long can we travel — these may be the only two facts we must know.

Passenger comfort will be at its greatest with air-conditioning facilitated by the same robot fuel cell energy source not borrowing on horsepower and performance. Tinted glass throughout the panoramic greenhouse will minimize glare and give a soft muted view.

Much has been predicted in the way of robot highways for the future — electronic magnetized bands which will guide the touring car from New York to Chicago without the requirement of the driver. I am not one to leave the romance of the driving of an automobile so quickly. Man likes to be in command of his steed whether it be automobile, power boat, or airplane.

I predict that steering will remain within his grasp. A cantilevered boom or arm with an aircraft type control may reach from the center line instrument board sideways to the driver's seat. This boom may be pivoted as on certain small aircraft of today so that the steering device can be passed across the cockpit to the passenger on the furthermost side, the co-pilot of "Utopia." The smooth flow of cell power without need for automatic transmissions or gear changing of any kind will be nostalgically reminiscent of the steam car both in quietness and acceleration.

In covering the market potential for this People's Car of 1970 I predict that a simple change in roof design and an elimination of the rear deck cover will provide a nine-place utility station sedan to cover the needs of the masses. An interesting and usable touch will be in the sliding telescopic roof, one-half of which moves forward into the other, providing either an exposure to the sun or the ability to load this area as a pick-up truck. This feature precludes the problem of low headroom as we know it in a station wagon of today for loading large objects.

In summation it should be pointed out that this is only one general concept for a low-priced high-volume mass produced vehicle based on the breakthrough assumption that the fuel cell powerplant in compact form can be located in strategic areas of the skin and that this vehicle in two forms — sedan and station wagon — would cover the needs of good clean ground transportation for all people. It does not, for the moment, provide for multiple appearances, obsolescence, or extreme individualization. This does not preclude the design of other vehicles based on the fuel cell method of propulsion of different sizes and different configurations for different personal desires. There could be volume run production on fuel cell sports cars, limousines, and small busses so as not to predict a "Utopia" only of the regimented look. This is merely an industrial designer's viewpoint on one way to produce a practical, reasonably-priced passenger car under the premise conditions — some features and details of which can be translated into different manufacturers' identities.

To Order Paper No. 303A . . .
from which material for this article was drawn, see p. 6.

Reliability Hinges on Management Disciplines

Based on report by secretary

L. S. FRANKLIN
Convair Astronautics

MANUFACTURING reliability programs attempt to establish a system of management disciplines based on:

1. Failure experience.
2. Reliability discipline.
3. Cost effectiveness.

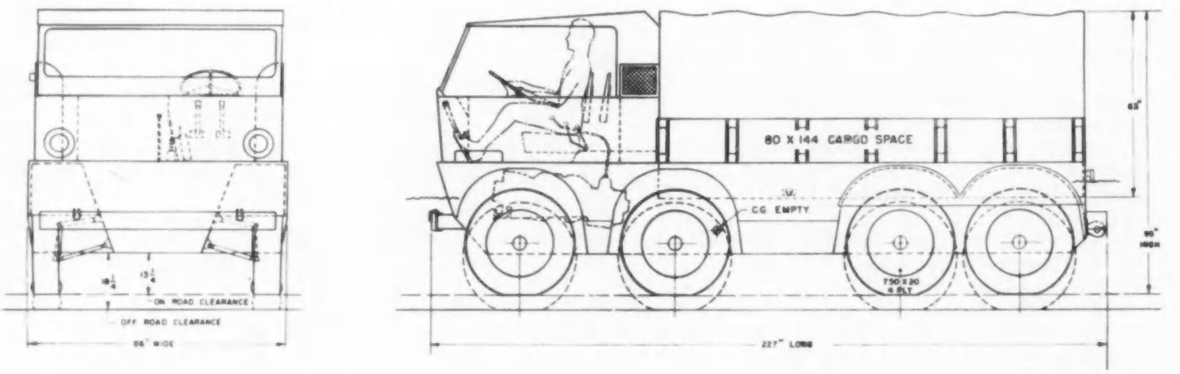
Case histories of failures provide a strong foundation for reliability programs. New types of failure are rare. When expressed in terms of employee errors, most have occurred before.

The only way management can prevent failure recurrence is by having formal directives, procedures, and instructions — and by demanding compliance to these. Thus it is necessary that reliability disciplines fit into the line organization and pattern of authority of a company.

Although the price of research, development, and manufacturing may be increased by reliability programs, the total cost of the manufactured part, installation, maintenance, and operation must be reduced. This is cost effectiveness.

Serving on the panel which developed the information in this article, in addition to the panel secretary, were: chairman **D. R. Archibald**, Convair Astronautics; cochairman **E. P. Coleman**, University of California; **C. V. Armstrong**, Convair; **L. W. Ball**, Boeing; **W. E. Campbell**, Aerojet-General; **W. E. Cox**, Northrop; **E. J. Lancaster**, Air Force Ballistic Missile Center, Los Angeles; **R. F. Martin**, North American Aviation; **H. Schneiderman**, Aerojet-General; and **R. G. Paul**, Douglas Aircraft.

(This article is based on a report of one of 14 aerospace manufacturing forum panels. All 14 are available as a package as SP-333. See order blank on p. 6.)



CHARACTERISTICS

CURB WEIGHT (EST.)	4544 LBS.	ENGINE	105 HP GROSS 94 HP NET
PAYLOAD	5350 LBS.	TRANSMISSION	4 SPEED MANUAL
TOWED LOAD	5000 LBS.	TRANSFER	2 SPEED
GROUND CLEARANCE	13¼ HIGHWAY 18¼ CROSS COUNTRY	AXLE	DOUBLE REDUCTION
PERFORMANCE	3.5% GRADE AT 30 MPH AT G.T.W.	TIRES	8.65 WIDE - 37½ DIA.
ROAD SPEED	1½ TO 55 MPH	SUSPENSION	INDEPENDENT, VARIABLE RATE WITH AIR COIL SPRINGS
WATER SPEED	5.2 MPH	BODY FRAME	ALUMINUM HONEYCOMB UNITIZED CONSTRUCTION

This new military 2½-ton vehicle has been built primarily as a Arsenal, it is on its way to test at Aberdeen Proving Grounds,

Novel features abound in

Selection of bonded honeycomb body-frame and handling of interest. 4-cyl, opposed aluminum engine has cylinder. Unusual arrangements in

Based on papers by

T. J. Bischoff and R. D. Arno
Ordnance Tank Automotive Command

S. J. Pearson
Whirlpool Corp.

and

T. R. Gondert
Stevens Institute of Technology

THE XM521 experimental 2½-ton military truck, soon to be tested at Aberdeen Proving Grounds, is primarily a means to present new design features and techniques for test and evaluation. Designed at Detroit Tank Arsenal with the cooperation of the automotive industry, this new test rig embodies many unique features and design techniques.

Of particular interest is use of bonded honeycomb panels for the body-frame design. The way design criteria for the vehicle's swimmability were laid down and achieved are also of special interest.

Honeycomb Body-Frame Structure

Chief advantages found to result from use of the bonded honeycomb structure in the body-frame design are:

- Smooth, unbroken surface.
- Good appearance.
- Superior insulating qualities.

means of testing new design concepts. . . . Designed at Detroit where tests will continue throughout most of 1961.

Army's Design-Testing Truck

swimmability decisions are of special

separate head for each

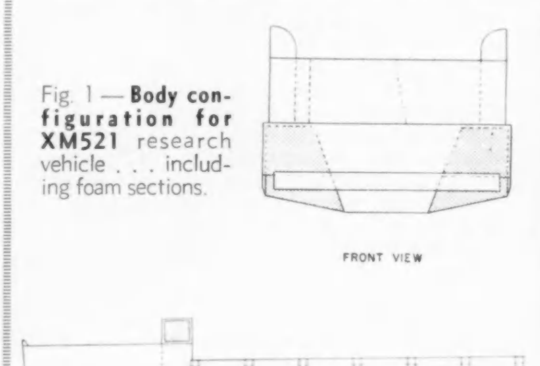
front axle system.

The honeycomb, it was found, has good energy absorption characteristics, as well as buoyancy. Yet it can be fabricated from light, heat-treated, corrosion-resistant material.

Considerations leading to choice of the honeycomb body-frame structure were several. Steady improvement of adhesives in recent years have reduced the cost of bonding. Still more new, improved adhesives, it seems likely, will reduce future bonding costs even more. Besides, the designers say, it is possible right now to produce this particular honeycomb structure at very competitive costs . . . as compared with other unitized-structure designs common in competitive military vehicles.

Also, designers found, this honeycomb body-frame concept (as shown in Fig. 1) fully meets the requirements for optimum body configuration of the vehicle laid down to start with. These included the

Fig. 1 — **Body configuration for XM521** research vehicle . . . including foam sections.



Army's Design-Testing Truck

. . . continued

drive-train and the powerplant shown in Fig. 1 . . . and an expectation that normal cargo loads would be 5000 lb with densities of 80 lb per sq ft.

The satisfactory honeycomb panel designs were accomplished by realizing the following conditions:

1. Sandwich panel skins are of sufficient material thickness to withstand calculated stresses.
2. Cores are of such material and thickness that overall panel buckling, shear failure, or excessive deformation will not occur.
3. The cell sizes of the core is small enough so that dimpling or buckling will occur inside the cell spaces.
4. The core and bonded sandwich panels have properties of flatwise tensile strength, comparative strength, and flatwise modulus of

Specifications . . .

THE NEW XM521 EXPERIMENTAL 2½-ton MILITARY TRUCK has been designed with an eye to lightweight, compactness, swimmability, air-transportability and droppability, minimum fuel consumption, mobility, low cost, and soft ride.

Its ratio of payload to curb weight exceeds unity, due to its ultralightweight. The suspension is a simple combination of air and coil spring with variable-rate qualities and good wheel deflections. All suspension, axle, brakes, hubs, shafting, and wheel components are interchangeable all around. Loading height is only 32 in. Interior height to top of cargo bows is 63 in. Overall height of 93 in. is lower than any comparable truck.

The braking system is designed to produce a deceleration rate of 17.25 ft per sec^2.

The vehicle is designed to carry a driver, an assistant driver, and, either 14 fully equipped troops or 5000 lb of cargo. When loaded to its specified gvw, it will tow 5000 lb.

The 4-cyl, aircooled, horizontally opposed aluminum engine is coupled to a 4-speed synchromesh transmision located directly under the cab. Power is transmitted to a 2-speed transfer case at the center of the vehicle; then fore and aft to double-reduction independent-suspension type axle carriers.

A split-type cylinder block is used, and each cylinder has a separate individual barrel and head. Each head carries its own valves and rocker arms, which are conventionally operated by push-rods. Two V-belt-driven blowers for cooling are used — one on each bank of cylinders.

Intake manifolds are connected to the oil lubrication system for inlet air preheat. The generator is mounted within one of the blower fan housings.

Engine cooling air and carburetor air are directed to the engine through the intake tunnel at the front of the cab. The dry-felt-type air cleaner is under the dashboard inside the cab. Clean air comes initially from the head of the cooling air tunnel inlet. Tunnel opening is 168 sq in.; vehicle outlet stacks, 216 sq in.

The oil cooler is located at the air inlet tunnel. The remote engine oil sump is mounted in foam in the left front body sponson. The muffler is in the right side of the air outlet stack.

The transmission is a slightly modified, commercially available, 4-speed, manual shift unit — with second, third, and fourth gears synchronized. The transfer case also is a redesign of a case available to industry. It is a 2-speed unit with ratios of 1.00/1.00 and 1.866/1.00. It is independently mounted behind the main transmission, to furnish added reduction and provide a drive to both front and rear axles.

The axle gear carrier assembly consists of a drive through a double-reduction unit incorporating a limited-slip differential for an independent suspension axle. This new design can be used in any of the four positions of an 8 × 8 vehicle.

The conventional hydraulical service braking system consists of a brake-pedal master cylinder, lines and fittings, and brake assemblies — each of which has a wheel cylinder, two brake shoes, backing plate, and other parts.

The two front axles are steered in the XM521 design. Novel are two arrangements in this system:

- The main tie-rod connecting links pass straight through the body via the wheel suspension castings. Connecting tubes and boots provide the tunnel for passage of the tie-rod links and keep water from entering the body hull while the vehicle is swimming.
- The safety-lock device (mounted on the steering column for water operation) can be engaged or disengaged at driver option. Feedback torque reaction is taken by the column support into the cowl.

Two 10-gal aluminum fuel tanks are located in the center sponsons of the body, and water propulsion is through a twin-propeller counter-

elasticity, so that no wrinkling of facings can occur.

Compression Loads

When it was determined in the design phase of the XM521 that a particular panel was subject to end loading only . . . or if the end loads were considerably greater than the bending and shear loads, the following procedure was applied:

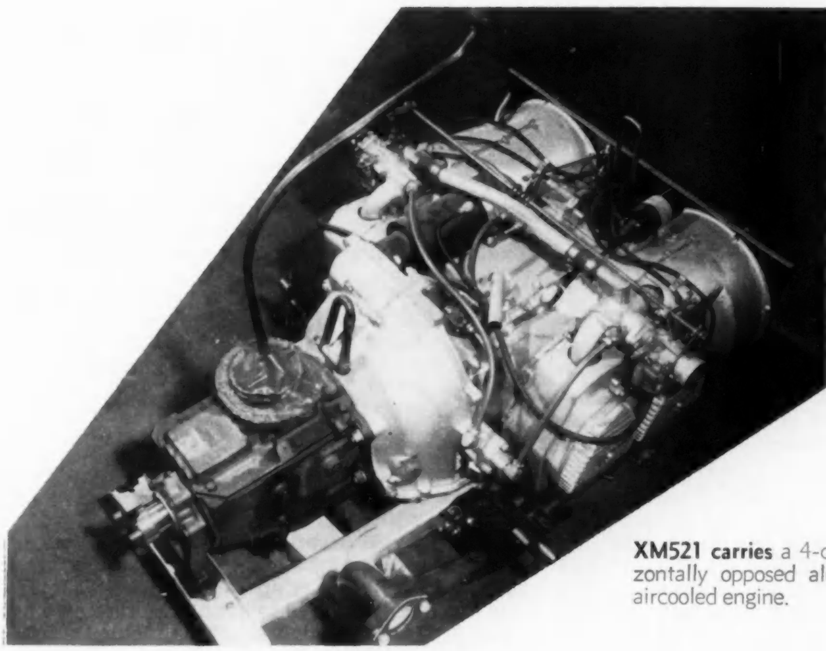
1. The size of the panel was established; its range of thickness was determined.
2. The values for the core and facing skins were calculated.
3. The panel dimensions and core density were reviewed so that there was no possibility of failure by face wrinkling.
4. The facing stress at which buckling occurs was calculated. If the buckling stress was less than the compressive yield strength, the face thickness was increased. Then the panel strength was calculated by multiplying the effective area

rotating drive located in the rear of the vehicle. It is driven through the transfer case and DTO under full engine power.

The 6.90/1 axle ratio finally selected is one of many XM521 design features determined with the aid of the high-speed computer equipment system, now regularly in use at the Detroit Arsenal. To meet requirements, the ratio had to provide: (a) 3% gradeability at 30 mph with rated cross-country payload and towed load; (b) 60% gradeability with rated cross-country pay load; (c) maximum speed of at least 50 mph.

Several axle ratios, including 5.40, 6.60, 6.90, and 7.20, were selected within the physical limits of the axle design to be used. Each of these items was "run on the computer," and printouts were made showing velocity, time, distance, transmission rpm, engine rpm, output torque at wheels, tractive effort, drawbar pull, gear ratio, acceleration, and gradeability. Curves were plotted automatically with a dataplotter in such forms as mph versus time, net tractive effort versus speed, and drawbar pull versus speed.

This information provided a sound basis upon which to make an evaluation of the individual gear ratios and to judge the merits of each.



XM521 carries a 4-cyl, horizontally opposed aluminum, aircooled engine.

Army's Design-Testing Truck

. . . **continued**

of the panel by the allowable compressive stress of the facing skins.

Overall panel buckling was determined by calculating the allowable buckling stress from the approximate formulas:

$$F_{CR} = \frac{P}{t_1 + t_2} \qquad P = \frac{\pi^2 D}{a^2 + \frac{\pi^2 D}{t_c G_c}}$$

where:

F_{CR} = Buckling stress

t_1 and t_2 = Thickness of facing skins

P = Load lb per lineal in.

D = Bending stiffness of sandwich panel

a = Panel or column height

t_c = Thickness of core

G_c = Core modulus of rigidity

Although the above formula for allowable buckling stress is only approximate, it indicates those properties of the sandwich panel which affect column strength. If the column is expected to operate through a wide temperature gradient, a correction should be made for this factor.

In the design of the XM521 body-frame structure, it was desirable for the panels to have a higher buckling strength than the compressive yield strength. One of the following procedures was followed to increase the panel buckling strength, depending on individual application:

1. Increase the modulus or density of the honeycomb core.
2. Increase the thickness of the facing skins. This usually results in a prohibitive increase in weight.
3. Increase the core thickness. This is the most effective way, since only a little increase in weight results.

Fabrication

The final XM521 body-frame design is fabricated from 24 flat, bonded panels (two of which were formed after bonding) . . . and one curved body panel. These panels comprise the basic structure, and are joined by a combination of riveting and bonding with room-temperature, curing adhesives. This construction can properly be described as a "torque box" and upper-deck structure, which comprises the main load-carrying members. Other panels serve only as secondary structures.

The lower panel of the torque box is designed to withstand loads from the drive train and propellers. The two side panels of the torque box withstand suspension-arm, shock-absorber, and coil-spring loads . . . also, the loads transmitted from tow hooks, lift hooks, bumpers, bumperettes, and pintle. These three panels, together with the upper deck panels, three differential access doors, and propeller structure — when assembled — comprise the torque box.

The cargo floor panel is loaded in bending, and a correspondingly high shear flow is developed locally around the panel, due to attachment of the torque box. (Preliminary design calculations and tests were made to determine the thickness of the facing skins needed to minimize denting due to mishandling of cargo.)

To fully seal the body against water during operation in water, scuppers for draining water from the cab were added. Sponsons were filled with a low-density, closed-cell, polyurethane foam to guard against water entry in the wheel well area, which is exposed to rock damage. The foam, a two-part liquid, is mixed and applied inside the sponsons. Then it is expanded at about a 20/1 ratio over its liquid volume to fill all voids. Eighty-three pounds of foam are required.

Achieving Swimmability

All of the six swimmability criteria originally laid down are met reasonably well in the final design; some of them perfectly.

The vehicle as actually designed, for example, can enter the water from a 60% slope at 10 mph; or from a 20% slope terminating in a 4-ft vertical drop at 25 mph . . . exactly as delineated in the original criteria.

The vehicle can cross water with a maximum speed of 5.2 mph . . . which is 1.8 mph less than aimed at. But 5.2 mph represents an acceptable speed — and is considerably in excess of speeds normally attained by this type of vehicle.

The requirements of responding well to steering, resisting tipping (good stability), and resisting sinking also are well met in the final design. The stability, for instance, is adequate for this type of vehicle. It can be driven across water without turning over, although due care must be given to the method of loading and the method of handling the vehicle while in water.

Once across the water, the vehicle can get onto a bank without relying on a prepared exit. There is sufficient tractive effort available from the wheels, coupled with the output from the propeller.

Power Train in Sealed Hull

During the initial concept studies, several hull designs were considered. One type had all the running gear outside the hull. It was decided, however, that this would unduly raise water drag and, incidentally, subject these components to increased abuse in cross-country operation.

It was finally decided to install the complete power train inside a sealed hull. This yielded a smooth bottom, desirable both in water operation and for off-road mobility. Also, it increased flotation within the limitations of overall package size. The hull was laid out as a wet deck design; the cargo is loaded on

top of the flat deck and any water taken aboard is simply expelled over the sides. This is quite similar in concept to a sealed cigar box with cargo placed on top. The engine and power train cooling air was brought in at the front of the open cab and directed out the rear of the vehicle. A 1/8 scale towed model of this first XM521 concept was tested at Davidson Laboratory, Stevens Institute of Technology early in 1959. Towing tests in smooth water indicated that the vehicle, while basically good, could stand a lot of improvement. The water buildup at the front — the bow wave — flowed intermittently across the open cab floor and may well have flooded the air intake system as well as proving annoying to the driver. Furthermore, at some 6 mph, the bow wave would start to flow continuously over the front of the vehicle, causing it to nose down further and try to dive under. Various coamings around the cab were tried, and these were found to be effective in preventing this nosing down tendency.

Tests on the towed model indicated that a water speed of about 7 mph would be realized if an overall propulsion efficiency of about 25% could be attained with a powerplant that delivered 100 shaft hp.

Propulsive efficiency is determined as follows:

$$\text{Propulsive efficiency} = \frac{\text{effective hp (test data)}}{\text{shaft horsepower}} \times 100$$

and

$$\text{Overall efficiency} = \frac{\text{effective hp}}{\text{installed hp}} \times 100$$

At this time the propeller installation was envisioned as an over-the-stern drive, like an outboard motor, with the prop centerline 11 in. below the bottom of the hull. The propeller would have to be retractable for land operation.

These tests resulted in recommendations that:

1. A coaming should be provided around the driver's compartment to protect the driver from casual water and to shield the cargo area.

2. Engine cooling air inlet and outlet ducts should be inclosed within this coaming and be well protected from water.

3. The practicality of an over-the-stern drive similar to that used on the amphibious Volkswagen of World War II should be investigated.

Armed with this preliminary information a redesign of the body structure was undertaken as follows:

1. A full coaming, 22 in. high, was added around the driver compartment.

2. Cooling air was ducted from inside the driver compartment over the engine and out a duct at each rear corner of the cab area.

While other design changes were made at this time, the primary change being from a 6 × 6 to 8 × 8 wheel arrangement, these stemmed from the concurrent mobility and layout investigations.

Resistance and effective horsepower curves showed that a propulsive efficiency of some 35% with the intended powerplant of 80 hp delivered at the shaft would be necessary to realize the desired 7 mph. Practical propeller tunnel design resulted, however, in an efficiency of approximately 15% and a water speed of 5.2 mph with the 80 shaft horsepower available.

Acceptable Stability Achieved

Tests of the basic vehicle showed it to be quite stable. Results of tests in the loaded condition were another story. While the most dense cargo (80 lb per cu ft) yields a fair stability, since high density has the effect of lowering the height of the cargo c.g. with respect to the vehicle, the lighter cargo (40 lb per cu ft) yielded a very marginal stability with top deck loading.

A design study aimed at alleviating this marginal stability showed that it was feasible to use a semidepressed deck loading. This increases the stability to a level that can be lived with, although core must be exercised with the low density cargo.

In a further attempt to improve stability, fender skirts were added to the rear wheels. The skirts had a definite and desirable effect on the stability.

The final stability, while not outstanding, is acceptable and is about all that can be anticipated within these design limitations: semidepressed deck, limited width, and high ratio of cargo to vehicle. This increased stability, resulting from the size of skirts, is evidently a result of the airtight attachment between the skirts and the body of the model. Thus, entrapped air and water under the skirts contributed to the righting moment.

The curves were smoothed out and the angle of maximum righting moment increased from 18 deg without skirts to 24 deg with skirts.

Problems in the Water

Design problems resulting from the vehicle being in the water are the same as those of a boat. It must float . . . and it must be propelled across stream. Then, having crossed the stream, it must be able to get out of the water and on to the stream bank.

Unsinkability in this design is provided by an unusual body design approach. Urethane foam sections in the sponsons of the body (Fig. 1), together with the other displacement elements, provide unsinkability up to a cargo density of 125 lb per cu ft.

For propulsion, a final-drive arrangement with a twin propeller drive was finally decided upon. It was chosen because it was seen as combining good efficiency with ability to protect the propellers by enclosing them within the outline of the hull. Engine rpm is 3800. Propeller rpm is 2250; transmission reduction 1.686 (third gear); propeller pitch 8 or 9 in.

To get out of the water, the vehicle's wheels are engaged so that they will assist as soon as contact is made. When the vehicle starts to leave the water, the stern is forced downward (on steep slopes) submerging the rear. (For this reason, the air exhaust outlets were moved to the driver's compartment.)

To Order Paper Nos. 273A,B,C & T46
from which material for this article was drawn, see p. 6.

A corrosion-proof metal

Based on paper by

Herbert D. Van Sciver

Budd Co.

ALL the elements needed to produce a corrosion-proof, all-metal automobile body exist right now. But improvements in both materials and manufacturing methods must come before actual production of such a body can be realized. Stylists, designers, and manufacturing men will cooperate in bringing about the needed advances.

Materials and fabrication methods unfamiliar to existing production facilities are sure to be involved in the final breakthrough. Also, new design data must be developed to take full advantage of new materials and joining methods. But we're pretty sure to be producing a corrosion proof body before 1970.

Forming

Materials with higher corrosion resistance than low-carbon steel, for example, will be affected by the forming process in different ways . . . and, in turn, they will affect the forming process.

Take SAE 1010 steel as a standard, because current body designs are based on how 1010 can be formed. Compare the forming properties of 1010 and some more corrosion-resistant materials:

	SAE 1010	Coated Steel	Stainless Steels			Al
			200	300	400	
Yield Strength (X1000)	25–30	25–30	55	40	40	13
Ultimate Strength (X1000)	40–45	40–45	105	90	70	28
Modulus of Elasticity ($X10^6$)	29	29	28	28	29	10
Elongation, %	35–50	35–50	55	60	25–30	25–30
Yield/Tensile Ratio	0.55	0.55	0.52	0.44	0.55	0.46

Any of these materials whose properties are less desirable than those of 1010 impose a limitation on both designer and manufacturer. Conversely, any improvement in properties allows more flexibility.

Galvanized and nickel coated steels, properly processed, have the same drawing qualities as the uncoated metal. Only one change has been noted — the zinc coating acts as a lubricant and this must be accounted for in blankholder shape and pressure if wrinkles are to be avoided.

The 200 and 300 series stainless steels are without question the best drawing materials available. A very large available elongation, coupled with a favorable yield-tensile ratio, allows extreme stretching without local failure. The higher ultimate strength and yield strength — particularly the 200 series — will require higher blankholder pressure and greater punch loads by about a factor of 2.

The 400 series stainless steels will impose some shop problems, since the higher yield and ultimate strengths do not improve the yield-tensile ratio and the elongation is less than with 1010. The 400 series is limited to the less severe draws where multiple operations are permitted.

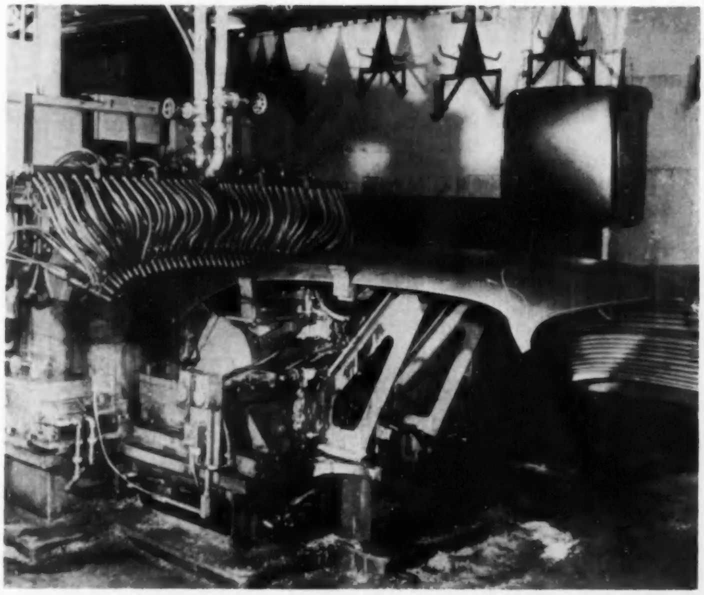
The corrosion resistant aluminum alloys have about the same limitation as the 400 series stainless steel. Although there is a favorable yield-tensile ratio, the available elongation is less than 1010 steel and, in some grades, there are tendencies toward galling in the die. The low modulus of elasticity indicates that particular care must be exercised to avoid wrinkles and excessive springback.

Any of the plastic coated steels will stretch the same as uncoated material. Flow through the blankholder, however, imposes some problems and formations are limited to pure stretch forming, bending, or rolling.

We must rule out deep drawing for ceramic coated steel. While the ceramic coating may not interfere with the drawing process, the coating will certainly not survive this treatment.

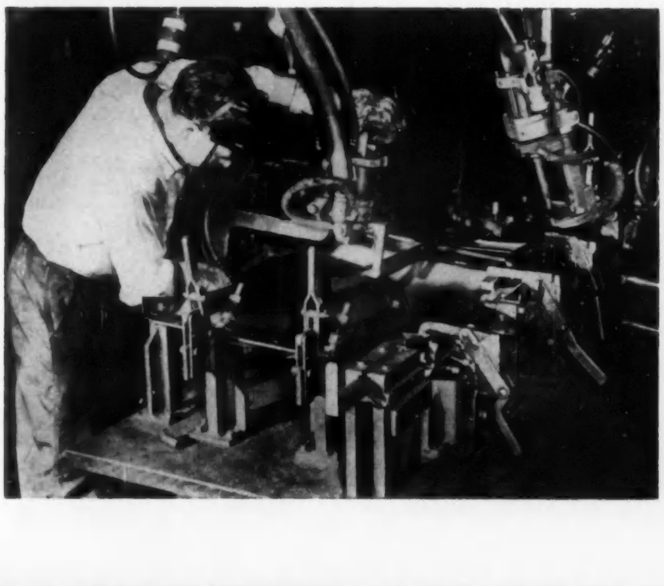
Materials with a protective coating such as galvanized, nickel coated, aluminized, or plastic coated steel and clad aluminum, are corrosion resistant as long as their coatings are unbroken. Sheared edges,

body . . . Why not *NOW*?



Automotive subassembly — often done in welding fixtures which allow many spot welds in a single operation — places certain limitations on use of materials for corrosion resistance.

Portable welding guns provide another method by which automotive spot welding is often done. . . . Here, as in other spot welding procedures, limitations in welding current and electrode force affect selection of materials for corrosion resistance in automobile bodies.



punched holes, score marks, and sometimes severely stretched areas, constitute potential corrosion areas. This is offset in galvanized and aluminized steel by the galvanic protection of the coating.

Welding

Design and joining methods for handling the sheet steel from which current automobile bodies are made have progressed side by side for the past 30 to 40 years. It's difficult to think of sheet metal without thinking of spot welding. This alliance places some limitations on the choice of materials. Compare:

0.040-in. Sheet	Current	Electrode Force	Surface Condition	Electrode Life
SAE 1010	8000	500	Free of dirt and rust and light oil	5000
18-8 Stainless Steel	5000	900	Free of dirt	5000
400 Series Stainless Steel	6000	800	Free of dirt	5000
Aluminum	30,000	600	Chemical or mechanical oxide removal	300
Galvanized SAE 1010	12,000	700	Free of dirt	1000
Nickel-Clad SAE 1010	10,000	600	Free of dirt	5000
Aluminum SAE 1010	11,000	700	Chemical or mechanical oxide removal	300

• ALUMINUM presents almost insurmountable problems in spot welding, because of (1) the very large currents required; (2) the relatively low electrode life; and (3) the need for mechanical or chemical cleaning shortly before welding. (Aluminum can be welded quite satisfactorily — but not on the type of equipment common to automobile body assembly.)

• STAINLESS STEELS present no problem. Their inherently clean surface makes them even easier than low carbon steels to weld.

• NICKEL-CLAD STEELS fall into the same category as stainless steels in this regard.

• ZINC AND ALUMINUM-COATED STEELS also fall within the electrode force and welding current limitations of automotive assembly practice . . . but the coating must be sure to adhere to the electrode — and aluminized steel needs a preweld cleaning to remove surface oxide.

• STEELS PRECOATED with organic primers or zinc-base primers present an electrode contamination problem under automobile conditions . . . and also require the primer either to be conductive or sufficiently mastic to be displaced by the electrode and thus make a good electrical contact with the steel.

Areas that retain moisture, such as crevices, are of major concern in corrosion protection, yet are the most difficult to seal off in subsequent painting operations. The very nature of resistance spot welding insists that parts to be joined be lapped . . . which produces crevices. It is not practical to make flush-butt spot welded joints.

Crevice-free joints can be made by arc welding — which automotive practice usually confines to chassis components and other heavier members. Arc welding becomes more critical as the gage becomes thinner . . . and it certainly isn't as fast as spot welding.

Adhesive bonding

Adhesive bonding is the most rapidly developing method of joining metals. Even more rapid progress in its application is hindered because:

- Adhesives must be applied to clean, dry surfaces — a condition seldom met in automobile assembly.
- Parts must fit over the entire surface to be bonded. There will be no spotwelding gun to act as a clamp or force pieces together.
- Adhesives require either time or heat to cure and develop strength.

But there are remedies to each of these problems. Cleanliness will handle the first of the three listed. Besides, adhesives are being developed that will be compatible with oil films.

Design modifications may provide better fitting joints, although the fit-up problem remains a tough one. Many joints, for example, can be made self-fitting by a press clinching operation, such as is presently used in doors, deck lids, and hoods.

Special tools and fixtures may solve the problem of the low green strength and long setup time of adhesives. One tooling company, for example, has designed assembly fixtures incorporating induction heating coils which will cure the adhesive in a few seconds . . . in a time comparable with spotwelding assembly time. The heating action is mild, involving temperatures of only 350 F.

Aluminum-Steel Combinations

There has been a natural reluctance to combine aluminum and steel in automotive structures because of possible corrosion from electrolytic action. Besides, aluminum and steel are not compatible for welding. . . . Bonding, however, overcomes both of these objections.

There is every reason to expect improvements in both materials and manufacturing methods which will make possible a truly corrosion proof body on a production basis.

To Order Paper No. 281A . . .
from which material for this article was drawn, see p. 6.

Light May "Speak" in Space

Based on paper by

Klaus W. Otten

Wright Air Development Division

THE use of light rather than radio frequencies for space communication systems is a very attractive possibility since increased efficiency is promised. The higher frequencies of the light spectrum (above 20 kmc) can better meet the increasing range and information bandwidth requirements of future space communication links.

At these higher frequencies there is a basic advantage to be realized; higher antenna gain. Since gain increases as the square of the carrier frequency, for a given antenna size, power requirements are correspondingly reduced. This is a welcome factor as it aids in reducing system weight, a goal always sought in space applications.

Unhappily, the amount of noise intercepted increases with frequency along with antenna gain. Since one goal in designing a communication link is a specified signal to noise ratio at the detector output, introduction of noise must be avoided. Preventative measures include making the detector responsive only to the radiation within the emission frequency band of the transmitter. Also, background radiation, as intercepted by the detector, must be kept to a very small value.

To reduce the effect of the thermal radiation environment in which the system must operate, the carrier frequency must be carefully chosen. The carrier must be considerably higher than the peak thermal radiation frequency which occurs in the infrared band, the exact point being determined by the temperature of the immediate detector environment. Also, the carrier must be outside that portion of the thermal radiation spectrum for which the fluctuations exceed those of the signal itself.

Besides ensuring that a specified output signal to noise ratio be maintained in a given type of environment, the system must have a certain information bandwidth, and must operate over a specified range.

Influencing factors

When weight considerations set a practical limit on the apertures of the receiving and transmitting antennas, the properties of the system detector and its environment will determine how well the system works. Since the detector plays such a large part in the system, its operation, and the factors affecting its performance are of great interest.

The detector may be thought of as being a sort of photon counter, where the intercepted photons having sufficient energy cause electrons to be freed and made available for the output current. If each intercepted photon produced a free electron the quantum efficiency of the detector would be unity. In the ideal detector, the output signal is composed of electrons set free by the incoming radiation, with no electrons present from any other source. In this case the output signal to noise (S/N) *current* ratio would be identical to the S/N power ratio, ρ_{in}, of the input signal. Since the output power ratio, ρ_{out}, is proportional to the square of the output current ratio which in turn is equal to ρ_{in};

$$\rho_{out} = \rho_{in}^2$$

For the ideal detector the intercepted radiation is the only source of noise. Radiation energy is transferred in quanta of energy $E = hf$ (Planck's constant $\times$ frequency), and is generally emitted in a fluctuating stream, which can be designated by a Poisson distribution. It is these random fluctuations in the intercepted energy quanta that cause noise. *S/N* ratio of the quantized radiation signal is the ratio of the average number of intercepted quanta to the number of quanta representing the rms value of fluctuation.

If the link between the transmitter and receiver of the system is ideal, the only noise present in the intercepted radiation is the quantum noise originating from the quantized transfer of the carrier energy.

In the actual system neither the detector nor the medium linking the transmitter to the receiver are free of noise producing sources. The detector

operating at a non-zero absolute temperature will generate internal noise. This is manifested in the "dark current" present at the detector output, in the absence of external radiation. The immediate environment of the receiver will, at a non-zero absolute temperature, emit radiation which will be picked up by the detector, and there will also be a background radiation contributing to the amount of noise.

Depending on the type of detector, the type of operation, and the carrier frequency, one of these sources of energy is predominant. As an example, all detectors operating in the infrared portion of the electromagnetic radiation spectrum are performance limited by thermal radiation.

Another factor to be considered in the practical detector is that not all of the intercepted radiation will be converted into free electrons for the output. This is due to actual quantum efficiencies of less than unity.

All of these factors combine to determine the amount of power required at the detector input for a desired output signal to noise ratio.

In order to supply this power to the input of the detector, the transmitter must generate this power plus the losses incurred during transmission over the specified range. Other losses include signal attenuation due to spreading and scattering of the radiated energy.

Partial compensation of the transmission losses is provided by the gains of the individual antennas at each end of the link. In addition, the power requirement being inversely proportional to the carrier frequency, is an aid.

To take best advantage of the gain available from the transmitter antenna the signal must be coherent. This is defined as a signal generated by a regenerative process. In contrast, an incoherent signal has a random amplitude-time or amplitude-phase relationship and must consequently have a wide frequency spectrum. Devices for producing such signals are characterized by the regenerative arrangement of an amplifier and a filter.

Antenna gain and tracking

Other problems involved in the space communication system deal with the effects of antenna misalignment and its dependence on frequency. For two stations having relative motion and separated by large distances, the finite traveling time of the signal sets an absolute minimum requirement to the solid angle into which the transmitter antenna radiates. This minimum angle must be exceeded to permit mutual tracking and an uninterrupted flow of information. Theoretically the size of this angle depends only on the relative velocity component which is perpendicular to the vector connecting the two stations, but a more severe limitation may be imposed by the imperfections in the attitude and orientation controls of the antennas.

For a minimum angular coverage the maximum antenna gain is limited because there is an inverse relationship between the two factors.

(This article is based on part of an Astronautic Symposium developed jointly by SAE and the Air Force Office of Scientific Research. The Symposium is available only as a book, titled "Vistas in Astronautics — 1960." To order, turn to p. 6.)

Dunlop Caliper Disc Brake

Based on paper by

J. W. Kinchin

Dunlop Rubber Co., Ltd., England

THE latest Dunlop caliper disc brake for passenger cars features quick-release friction pads of a rectangular shape. Each pad is located in a parallel slot extending radially through the caliper so that the pads can be removed and replaced without dismantling the assembly. The pads are held in position by a clip fastened by a single nut and bolt or, if to be used on a racing car, by a quick-release pin.

The new design makes it possible to observe the condition of the pads without using external indicators. Substitution of a rectangularly shaped pad for the original circular shape gives a better distribution of the heat generated across the swept width of the disc. As shown in Fig. 1, the pad retractor mechanism is enclosed within the cylinder and the piston assembly. On brake release the piston is withdrawn by the retractor a preset amount into the cylinder, so that the pad to which it is clipped is brought correspondingly clear of the disc.

Necessity for rigid disc

The caliper brake is an outgrowth of the multidisc aircraft brake employing a floating disc. When the disc brake was applied to road vehicles it was undesirable to have the disc capable of axial movement

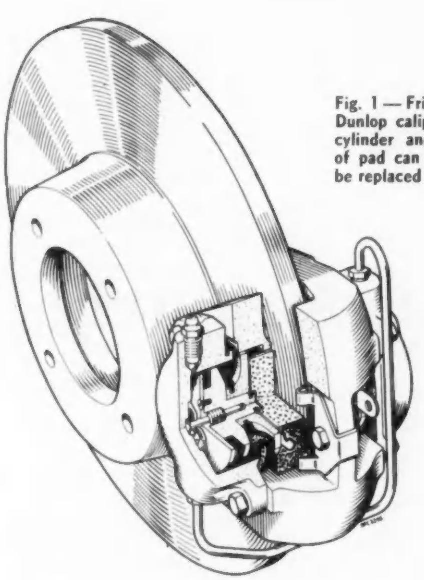


Fig. 1 — Friction pad retractor mechanism of the Dunlop caliper disc brake is enclosed within the cylinder and piston assembly. Wear condition of pad can be seen directly and worn pads can be replaced without dismantling brake.

Cost of production is still the greatest obstacle to disc brake adoption.

Objective of design, therefore, is to develop more economical units.

As an interim measure, disc brakes are being used for front wheels and drum brakes for rear wheels.

This "mixed" braking system is responsible for the spread of disc brakes from high-priced cars to cars in the medium-price range.

for Production Cars

because some side force, which can rise occasionally to a high value, is generated at the brake. Sideways movements of the disc would produce detrimental wear of the friction pads and probably knock back of the piston of a hydraulic brake. Even without appreciable side forces, the disc would drift one way or the other to contact the friction pads on that side, with double clearance on the other side. Even allowing for the knock-off of the disc from the pads during running, serious pad wear would arise.

The desirability of fixing the disc rigidly to the rotating member led to the caliper brake with opposed cylinders. The first brake of this type was built by Dunlop in 1951. The front unit was a one-piece caliper straddling the outer radius of the disc and mounted rigidly to the axle. The caliper was provided with three cylinders on each side arranged in directly opposed pairs. The six friction pads were circular and carried directly in the cylinder bores, the pistons operating directly against the back face of the pad. With this construction the opposed friction pads were loaded independently against the disc surfaces, and take-up of wear occurred without the necessity for a sliding disc.

Simplification of design

The rear brake was similar to the front except that it had two rather than three pairs of opposing cylinders and was fitted with a mechanical band brake acting on a groove in the outer rim of the disc to serve as a hand brake. This type of hand brake was later replaced by a lever-actuated brake operating with another pair of friction pads on the disc faces.

The next step in development was to make a simpler and more compact unit. Improvements in friction pad materials were allowing operation at high loadings so that the working surface area of the pad could be reduced. Accordingly, the next design had one pair of opposed cylinders and pads instead of three. Cylinder blocks were bolted to the outer faces of the caliper. A ball and socket connection was arranged between each piston and pad carrier plate to relieve the piston from any possible angular loading. Each cylinder block carried two retractor assemblies which act as return springs and automatically reset the pads on brake release to a predetermined clearance from the disc.

A feature of the separate cylinder is its provision for effective insulation for the piston seal and the hydraulic fluid against the heat generated by braking. It also allows a range of sizes to be used with one basic caliper design.

This is the general form of the brake, which now has quick-release pads of rectangular form for easy replacement already described and illustrated in Fig. 1.

To Order Paper No. 304B . . .
from which material for this article was drawn, see p. 6.

High-energy processes shape

Based on secretary's report by

C. W. Gipe

Ryan Aeronautical Co.

NEW, exotic, high-energy methods are shaping materials into the complex components needed by missiles and space vehicles. This article describes three of the more promising new techniques: electric arc forming, high-energy impact forming, and explosive forming.

Electric arc forming

The requirements for electric arc forming (commonly referred to as underwater lightening) are:

1. A source of energy such as a 110-v, 60 cps a-c lighting circuit.
2. A nonchemical package such as a bank of capacitors charged to the point where they will discharge.
3. A releasing mechanism for this power source.
4. A die, preferably of the split type.
5. A retainer for the die.
6. A forming medium such as water.
7. A vacuum.

The part to be formed is loaded into the split-type die, secured in a retainer, and either the forming medium is added, or die and retainer are positioned in the medium. Using a capacitor with a discharge of 4000 v and 1,000,000 amp and suspending the electrodes within the part, the current is turned on which charges the capacitors to a maximum within six seconds. This force is then discharged, resulting in a controlled force within the part to be formed of approximately 1,000,000 psi for two to three microsecond duration. Cost runs about 0.004¢ per shot.

The discharge force may be controlled by varying any of three factors:

1. The power source.
2. The size of the bridge wire between the electrodes.
3. The type of bridge wire. Bridge wires of aluminum, steel, and titanium have been used.

The discharge force may be used to form, shear, blank, bead, pierce, and flange, using tooling made of standard tool steel.

One advantage of electric arc forming is that it is an in-the-plant operation featuring complete safety when all operating rules are strictly adhered to. The unit can be made essentially foolproof through interlocking safety devices. In addition, the forming operation can be rightly controlled, resulting in a repeatable operation for forming very close tolerance parts.

Electric arc forming also reduces fabrication costs. Consider the following example. Fourteen production parts made by conventional methods required a total of 13.166 hours to fabricate. Using electric arc forming, this time was cut to 1.322 hours, resulting in a net savings of 11.844 fabrication hours.

The future for electric arc forming using one to two million volts and approximately four hundred thousand amperes is comparable to that of any forming method which produces large, close tolerance sheet-metal parts of exotic materials.

High-energy impact forming

The methods of high-energy impact forming or forging use a basic power source of the hydroelectric, electromagnetic, pneumatic, or mechanical type.

Using a pneumatic-mechanical combination power source, with a pneumatically activated cylindrical ram using the basic principle of differential air pressures coupled with accumulator pressures of 2000 psi, ram velocities of as much as 2500 fps can be achieved. Speed of the ram is dependent upon the size of the ram cylinder and the accumulator pressures employed.

Energy levels of as much as 1,500,000 ft-lb can be attained at the bed, base, or impact plate of the ram, with a repetitive cycle time of 30–60 sec.

To contain the large ram pressures without breakage, a dynamic restraint bed or base plate is employed. The bed is designed as an integral part of the assembly and indirectly connected to the pneumatically actuated cylindrical ram. The resulting force of this type machine can be controlled by varying the accumulator pressure and the dynamic restraint. Forming and forging are possible using tooling made of normal tool steel.

Advantages in using a high-energy impact machine for forging are:

1. Material can be forged to very close tolerances

space-age parts

with little or no machining required on the completed forgings.
2. Zero draft is required on tooling, resulting in less material waste during final machining and lower labor costs.
3. Tooling is simplified because all blocking operations are performed using the finished die.
4. Forgings have high structural integrity with fine microstructure.

Typical of the lower raw material and machining costs is the following example. Twenty-eight steel forgings made by conventional methods weighed a total of 383 lb. After machining the items weighed only 87 lb. Thus, 296 lb of material was lost in machining. Considering raw material price and scrap value, this 296 lb represents a major advantage for the use of the high-energy impact forging method. In addition, one must add to this the reduced labor cost of machining, since high-energy impact forgings have far less flash than conventional forgings and require little or no machining. Also, reduced heat transfer from forging billet to die because of lower cycle and dwell times results in less die wear.

The future of high-energy impact is in forming exotic materials. Research is being conducted on ceramic and powder metal compaction.

Explosive forming

The explosive forming method of shaping materials requires a die, blank, vacuum, explosive pressure media, and explosive charge.

Tooling for explosive forming must be rigid, yet flexible enough to withstand the force of the forming charge, reasonable in price, and available. The controlling factors in the selection of the tooling material are: the number of parts to be produced, part configuration, the type of material to be formed, and the size of the part. Materials commonly used include: kirksite, ductile iron, steel, plastic, and concrete.

The advantage of explosive forming is uniform work hardening, if all variables in the process are controlled. The future of explosive forming may well lie in the forming of hemispheres to 20 ft diameter, with the possibility of forming 30–40 ft diameter hemispheres using concrete dies faced with epoxy.

Typical examples of the explosive forming process include:

Tailpipes made of SAE 30321 stainless steel preformed as welded cylindrical tubes, formed in a split kirksite die held by a retainer.

Hemispheres made of 0.160 type 5086 aluminum in sizes to 70 in. diameters, holding variation to ± 0.008 in. and maintaining a minimum yield of 30,000 psi.

Tank domes of type AM355 stainless steel have been work hardened by explosive forming, transformed and aged, resulting in a minimum yield strength of 230,000 psi.

Pressure vessels have been explosive formed from rolled welded tubes using a split-type die and welding on formed ends. This method eliminates the unfavorable girth weld of pressure vessels. Thinning during the forming operation is eliminated by chem milling the welded cylinders prior to forming, thereby providing a uniform wall thickness on the completed pressure vessel.

Radar reflectors: explosive forming lends itself to the manufacturing of radar reflectors, capacitor plates, and electronic beam antennas. These parts are formed from single sheets with a requirement of an unmarred surface finish. Mirror finished aluminum often has been used for this type application.

Tubular stock has been threaded by this forming method, thereby providing an inexpensive locking joint for possible missile application where a welded flange is deemed undesirable. Deflected explosive shots may also be employed, forming flanges on cylindrical sections.

Helmets have been formed from special titanium alloy using the explosive forming process. The material is similar to 6Al–4V titanium and is formed at temperatures of approximately 1200 F. It has ballistic properties superior to that of most steels. Starting with a flat blank of 0.075 in. material, thinning was held to less than 0.007 in. The forming die was electrically heated and the forming media was sand.

Mass production in explosive forming may be achieved by the use of hydraulically actuated mechanisms, thereby competing with conventional factory procedures.

The future of explosive forming may well lie in the production of large parts made from tough materials. The only limiting factor at present is the die material and research is being conducted on all presently used materials including high-strength concrete for dies greater than 20,000 lb in weight.

Serving on the panel which developed the information in this article, in addition to the panel secretary, were: chairman **Floyd Cox,** Ryan Aeronautical Co.; co-chairman **J. W. Nicholas,** Lockheed Aircraft Co.; **E. W. Feddersen,** Convair; **A. Dunn,** Convair; and **J. P. Orr,** Ryan Aeronautical Co.

(This article is based on a report of one of 14 aerospace manufacturing forum panels. All 14 are available as a package as SP-333. See order blank on p. 6.

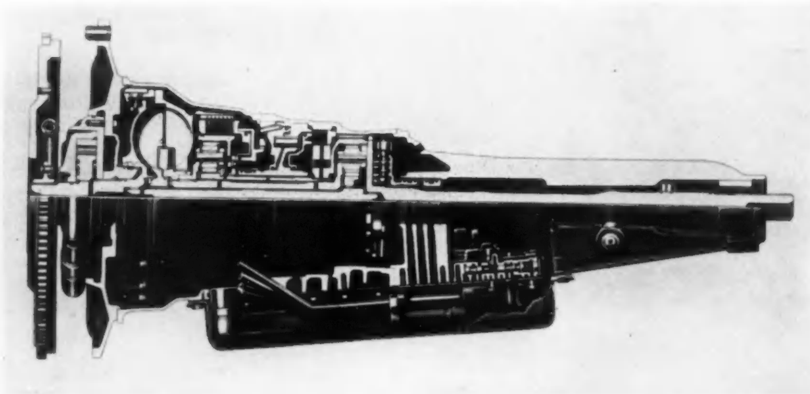


Fig. 1 — Cross-section of light-weight, compact, Hydra-Matic transmission developed for conventional sized cars. Weight is 132 lb, torque capacity 400 ft-lb.

GM develops light-weight, compact,

Based on paper by **W. B. Herndon**
General Motors Corp.

COMPACTNESS and light-weight feature the new Hydro-Matic transmissions developed by the Detroit Transmission Division of General Motors. The model, designated HM 61–10, was designed for use in conventional sized cars while the HM 61–5 was aimed at the economy class vehicle. Except for size and torque capacity the two transmissions are similar in general design and mode of operation.

Details of HM 61-10

The HM 61–10 is fully automatic having three gear speeds and a torque multiplying fluid coupling which gives a ratio coverage equal to a 4-speed transmission, but with two shifts instead of three. The transmission, as shown in Fig. 1, comprises a vibration damper, a fluid coupling with a torque multiplier, two simple planetary gear trains, one multiple-disc shifting clutch, one multiple-disc neutral clutch, one sprag one-way clutch, one overrun band, and a reverse-cone clutch together with the hydraulic system.

The vibration damper assembly is bolted to the engine flywheel and splined to the transmission input shaft, which is integral with the torus cover. This assembly turns at engine speed at all times. The torus driven member is splined to the mainshaft which, in turn, is splined into the rear unit sun gear through a resilient damper assembly. The damper assembly (Fig. 2) is a steel-jacketed, rubber cushion, which is pressed into the rear unit sun gear. The cushion has splines molded into it that fit closely to mainshaft splines. The mainshaft splines, in turn, fit loosely into the splines of the rear unit sun gear. This arrangement allows the damper assembly to absorb approximately 7 deg of torsional motion, compressing the rubber before the mainshaft and sun gear are in direct metal-to-metal contact with each other. The purpose of the damper is to break up torsionals and eliminate spline rattles.

Action of sprag assembly

The output shaft is doweled and bolted to the rear planet carrier assembly and its shaft, as can be seen in Fig. 1. The front carrier and torque multiplier are splined to the rear carrier shaft. The torque multiplier, front planet carrier, rear planet carrier, and carrier shaft all rotate with the output shaft.

The front sun gear and shaft are splined into the sprag inner race, which is integral with the rear unit internal gear. Any time the sprag assembly holds the sprag inner race from turning counterclockwise, the front unit sun gear and rear unit internal gear also are restrained from turning counterclockwise.

The sprag assembly is a one-way clutch preventing the inner race, front unit sun gear, and rear unit internal gear from turning counterclockwise, but it will overrun and allow these components to turn clockwise.

To get smoother shifting

Departing from the customary practice of having a ground member or fulcrum point for each torque-

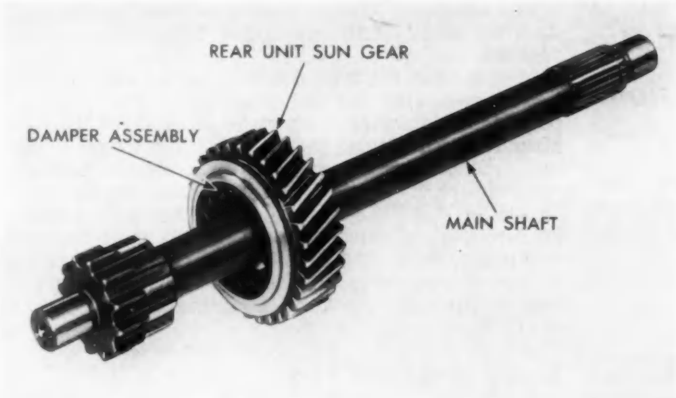


Fig. 2—Steel-jacketed, rubber cushion of damper assembly is pressed into rear unit sun gear. Molded splines on cushion fit closely to mainshaft splines. Assembly will absorb 7 deg of torsional motion.

Hydra-Matic transmissions

multiplying unit, the HM 61-10 has only one ground member for the entire range of forward speeds. The single, one-way clutch is the fulcrum point for the torque multiplier, and the first and second gearset. This reduces complications and costs and contributes to smoother shifting.

The neutral clutch drive plates are splined to the sprag outer race. The neutral clutch driven plates are splined to the transmission case so that whenever the neutral clutch is applied, the sprag outer race is locked to the transmission case. The front clutch drive plates are splined to the coupling drive member and the driven plates are splined to the front unit internal gear. Whenever the front clutch is applied, the front unit internal gear is connected to the torque drive member and is turning at engine speed. The steel plates of both front and neutral clutches are splined into the aluminum die-cast members.

Cone-type reverse clutch

The reverse stationary cone is keyed to the transmission case and so is the reverse piston, which is doweled to the case center support. The reverse cone, with angle of 13 deg, is splined to the front clutch housing which in turn, is bolted to the front unit internal gear. When the reverse piston is applied, the cone is clamped stationary, thus holding the front unit internal gear stationary. The combination of cone-type clutch for reverse and plate clutch for forward enables the vehicle to be rocked easily.

Fluid coupling features

The fluid member combines in one small 8-in.

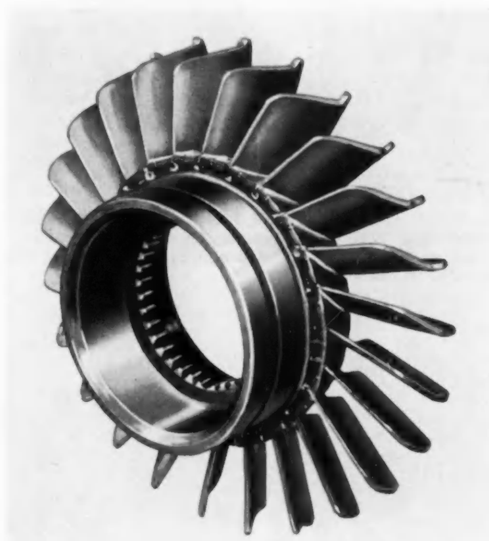


Fig. 3—Torque-multiplying coupling is splined directly to output shaft. Unlike most torque converters, it is not attached to a ground member through a free-wheel unit.

HERE are descriptions of the two new Hydra-Matic transmissions developed by General Motors for 1961 model cars.

The model HM 61-10 is being used in Cadillac, big Oldsmobile, and big Pontiac.

The HM 61-5 is found on the small Oldsmobile.

Hydra-Matic transmissions

. . . continued

diameter member all the functions customarily performed by three types of fluid members. These are:

A fluid coupling, which serves as a starting clutch but does not multiply torque.

The controlled coupling, which serves as a shifting clutch and replaces a friction clutch.

Fig. 4 — Partially self-energized, two-wrap band on the smaller transmission (HM 61-5) replaces the sprag-type one-way clutch, plate neutral clutch, and overrun band found on the larger model transmission.

The hydraulic torque converter, which acts as a starting clutch and multiplies torque to varying degrees.

In first gear, the fluid coupling serves as a starting clutch and also multiplies torque. The fulcrum point is not a stator in the true sense since it is not attached to a ground member through a free-wheel unit. The reaction member is a simple member splined directly to the output shaft, as seen in Fig. 3. In second gear the fluid coupling has no function. In direct drive, the engine torque is split through two paths, about 60% of it being directly mechanical to the output shaft and 40% of it a regenerative-torque through the fluid coupling to the output shaft.

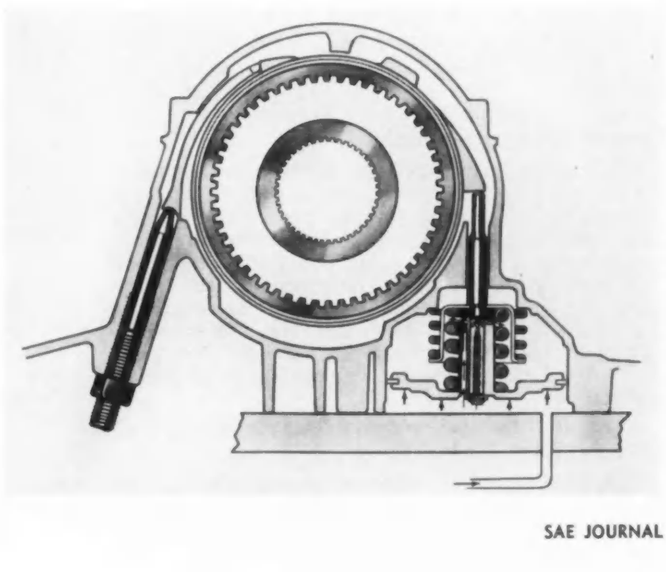
Details of the HM 61-5

The torque capacity of the HM 61–5, the smaller model, is 250 ft-lb, as contrasted with 400 ft-lb for the HM 61–10; the weight is 103 lb, while the larger model weighs 132 lb. There is also one major mechanical difference. In lieu of a sprag-type, one-way clutch, a plate neutral clutch, and an overrun band, the HM 61–5 combines all three units into a partially self-energized, two-wrap band, as shown in Fig 4. This band is released in neutral, direct drive, and reverse, and is engaged in first and second. It is the only reaction member for forward drive torque multiplication.

Because of its double-wrap construction and self-energizing effect, the band approximates the "one-way" action of a sprag clutch. It holds considerably more load in the reverse direction when the transmission is multiplying torque, and less load in forward when the coupling is filling and trying to pull the drum away from the band. The self-energizing action contributes to smooth shifting. The band servo, a self-accumulating, three-stage, operating unit, which functions as though it were a much larger unit, is shown in Fig. 5.

To Order Paper No. 290A . . .
from which material for this article was drawn, see p. 6.

Fig. 5 — Band servo, a self-accumulating, three-stage, operating unit, used on the small Hydra-Matic transmission.



Material drawn from a paper presented
at **SAE Chicago Section**
and at **South Bend Div., Chicago Section**

Turbine-driven amphibians of new design

. . . may answer military requirement for speedier land-sea operation

Based on paper by

Kenneth A. Austin and Louis S. Votre

Lycoming Division, Avco Corp.

TURBINE-PROPELLED hydrofoil or ground-effect vehicles could increase the speed of every vehicle in an amphibious operation from 10 to 40 or 70 knots and give a military commander equipment adequate to meet his modern tactical requirements.

Major speed increases are impracticable for displacement amphibians because of wave-making drag, which is a function of vessel length. For a reasonably practical wheeled amphibion length of 45 ft, the installed power of about 17 hp/ton must be doubled to raise water speed from 10 to 12 knots. If a vessel of the same length is designed to come out of the water and plane on the surface, an installation of about 100 hp/ton displacement is needed to gain a speed of 40 knots. Power for land use is seldom more than 15 hp/ton, so it is almost mandatory to have a separate low-power engine for economic land use.

Hydrofoils offer solution

The value of hydrofoils lies in their ability to lift a vessel hull clear of its wave-making drag and thus substantially increase speed for a given installed power. For an amphibian of the 45-ft size, the power requirement for 40 knots is about 50 hp/ton, increasing to 100 hp/ton for 55 knots. Above 65 knots cavitation becomes a predominant factor and the shape of foils and propellers must be altered to maintain efficiency. Even so, power needs rise sharply and would be up to 180 hp/ton at 70 knots for a 20-ton boat.

An important maneuver in amphibious operation is passage through surf and emergence on land, which only helicopters have been able to perform without interruption. Now, ground-effect machines or hovercraft, traveling low, on the phenomenon of high-lift augmentation of a powered "air cushion," can do this with ease and be equally at home over land or water.

Hovercraft advantages

The spectrum of hovercraft may range from heavy-payload vehicles operating at a height/diameter ratio of 0.01 to 0.10 to fast free-flying vehicles capable of flying at a height of several times their diameter for short periods. They can travel at speeds of 70–100 knots, unhampered by the cavitation problems of a water propeller. For a 70-knot cruise speed at 2-ft altitude, about 120 hp/ton is the apparent need for a 2-ton craft of seaworthy construction.

The hydrofoil craft emerges as a logical, efficient

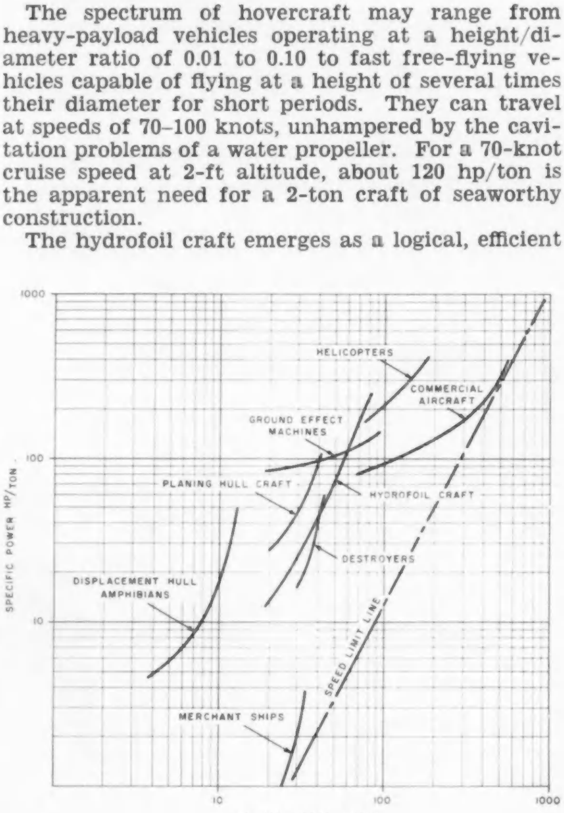


Fig. 1 — Specific power requirements of various transportation vehicles to achieve a given speed.

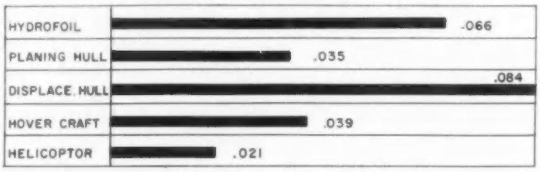
successor to the boat; the hovercraft accomplishes most of the roles of the helicopter in more economic manner. Hovercraft geometry appears to need length/beam ratios lower than hydrofoil craft and this may decide which vehicle can transit from the open beach into a normal road traffic system.

Case for the gas turbine

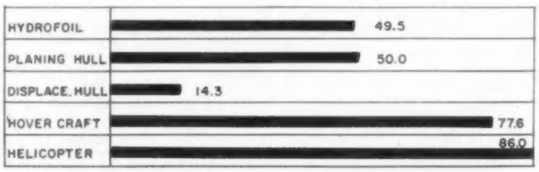
For purposes of comparison, Fig. 1 gives the specific power required for a given speed, and Fig. 2 compares the transportation efficiency of different vehicles. It can be seen that the specific power required for a 5-ton payload vehicle varies from 17 hp-ton for displacement hulls to 210 hp/ton for helicopters.

A desirable mission time is 5–6 hr. Assuming an engine and fuel allowance of 20% of vehicle gross weight, above 125 hp/ton the allowable fuel to go with a turbine of even 0.5-lb/hp specific weight is insufficient for more than 4-hr duration. At 200 hp/ton the endurance is down to 2.5 hr. Further analysis makes clear that gasoline engines of greater than 1.5-lb/hp specific weight cannot achieve adequate endurance above specific powers of 100 hp/ton. Diesel engines of 6.0 lb/hp reach their limit at 50 hp/ton.

In practice, the weight advantages of a gas turbine with an sfc of 0.60–0.70 lb/hp are such that the crossover point for weight and fuel compared to a turbocharged diesel is out to about 20-hr endurance at high power. For any endurance below this figure the gas turbine vehicle is superior in every way. For the 5-hr endurance just mentioned, a turbine of 1.0-lb/hp specific weight allows vehicles below 50-hp/ton specific power to increase their payload by 30% or reduce their size in comparison with equivalent piston-powered units.



1. COMPARISON — TONS PAYLOAD / HP



2. COMPARISON — CARGO DELIVERED PER VEHICLE
20 MILES TRIP. 12 HRS OPERATION

3. RELATIVE TRANSPORTATION EFFICIENCY. (1÷2)

Fig. 2 — Comparative transportation efficiency of various types of amphibious craft shows the superior relative efficiency of the hydrofoil and hovercraft.

New high-speed amphibian

Illustrative of turbine-powered craft is the new, high water-speed, wheeled amphibian designed by Lycoming and called the Hydrophibian (Fig. 3). It is a 5-ton, 4 × 4 gas-turbine powered vehicle capable of land speeds up to 55 mph, negotiating a 60% grade, and speeds over water up to 45 mph. It can go through surf as well as the World War II DUKW, and it has retractable wheels and marine drives. With a cargo space of 400 cu ft, it can recover from a 45-deg list while carrying a 10,500-lb Conex container. The hull is aluminum skin stressed. Its curb weight is 20,000 lb, and its gross weight is 30,000 lb.

Controls are simplified to two speed ratios forward and one reverse for land operation. The hydropilot adjusts the foil for take-off and maintains flight altitude; the driver can take off on land by simply advancing or retarding the throttle and maintaining directional control.

To Order Paper No. S270 . . .
from which material for this article was drawn, see p. 6.

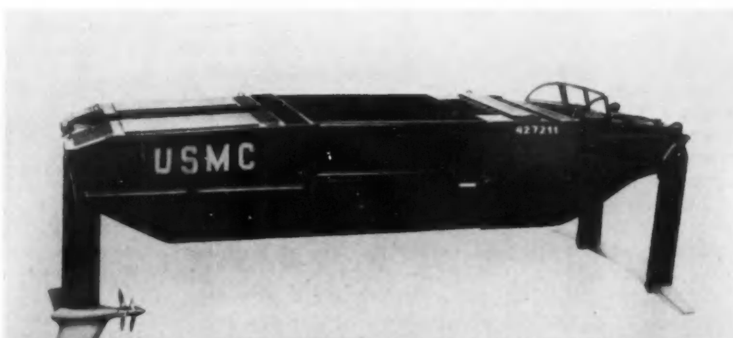


Fig. 3 — Lycoming Hydrophibian with wheels retracted and foil and marine drive in position for water travel. This craft can reach 55-mph land speed and 45 mph over water. It is powered by a gas turbine.

New roads influencing European bus design

Builders plagued by regulations, need to reduce smoke and odor, improve comfort, and cut costs.

Based on paper by **N. E. Nystrom**

AB Scania-Vabis, Sweden

EXTENSIVE modernization of highways is going to make it possible for European buses to carry higher axle loads, have greater width, and travel at higher road speeds, but these will not materialize until national authorities standardize road regulations which differ widely among countries as they do in the States.

West German regulations will probably be accepted by most European countries within five to ten years. These specify a maximum gross weight of 16 tons, overall width of 2.50 m (8.2 ft), and overall length of 12 m (39.3 ft) for a 2-axle bus. The length of single-deck British buses will likely be increased from 30 to 36 ft shortly and this will make rear-engine installation attractive.

Emphasis on safety

The Danish practice of using separate foot-brake systems for front and rear axles will probably spread to other countries. On the Scania-Vabis integral bus a steel plate guard is welded to the body structure inside the outer paneling in front of the driver and along the entire right side. The guard is so placed as to intercept the platform of a truck in the event of a collision. Regulations specifying a certain impact strength for truck cabs went into effect in Sweden on January 1. This will call for all-steel cabs of stronger than present construction. Similar regulations covering bus bodies seem imminent.

Noise and smoke control

In Britain, West Germany, Switzerland, and Sweden, special committees are working on the problem of noise and smoke control. The first problem to solve is a method for measuring noise level and smoke intensity, then to find out what is tolerable from the medical standpoint.

There are three approaches to the problem of diesel bus noise. They are:

- Improvement of fuel injection systems and combustion.
- Development of more effective mufflers and exhaust systems.
- Development of better sound absorbing insulation and methods.

Effective insulation will add to weight and cost, therefore, efforts should be directed primarily to the engine, then try to get a silent installation. From this point of view, the rear-engine installation is best suited.

Smoke and odors have become a great problem in many European cities. Next year the governments of Great Britain and West Germany will probably issue regulations covering the maximum permissible smoke and percentage of uncombusted exhaust fumes. Oil companies are working with lighter fuels, which seem to decrease the amount of toxic exhaust constituents. Generally speaking, the diesel offends less than the gasoline engine in the production of toxic exhaust constituents. The main problem worked on in Britain is to reduce the carbon monoxide content, and any success will automatically reduce the hydrocarbon constituent.

Influence of competition

The increase in ownership of private cars has cut severely into bus travel. Buses must, therefore, be made more attractive to hold or win back customers. Some of the steps taken to do this will be to lower bus floors for easier loading and unloading, employ air springs of the rolling type, reduce the number of standees, and dress up appearances so that buses appear less as the poor man's vehicle.

All this means increased costs at a time when bus revenues are shrinking, so economies must be sought at every turn. Since labor costs are the biggest item, the trend is to one-man, rather than two-men, operated buses. Efforts will be made to lighten vehicles and to make them more comfortable for the drivers. And, of course, a drive will be made to cut maintenance costs by improving engine accessibility, simplifying lubrication, using all-steel welded construction for easier repair, and designing for mechanical washing.

Standardization

Europe has too many types of buses. Standardization is needed, and much could be learned from American producers, even though American buses would not be particularly suitable. Further progress depends to a large extent on the willingness of bus operators to accept a reasonable degree of standardization.

To Order Paper No. 309B . . .
from which material for this article was drawn, see p. 6.

CHRYSLER engineers tell

how they go about

designing front suspensions

► **Here is a specific, practical, step-by-step description of how some of the industry's most experienced suspension engineers do their job of designing car suspensions.**

Based on paper by

R. R. Love and A. D. Bosley

Chrysler Corp.

THE DESIGNER of front suspensions for passenger cars works within a framework of a basic car package, established by top corporation management. Also, he works within the more specific definition of this basic car package, through which the chassis engineer has established his specific targets . . . weight, weight distribution, wheelbase, track, center of gravity, and approximate space allocation for the chassis units.

The suspension designer starts his work by combining the information on the new car proposal with the ride and handling criteria established by the ride engineers to establish estimated wheel loads, tire and rim sizes, wheel ride rates, and the bounce, pitch, and roll frequencies. These data define the basic car stability—which is calculated by the two degrees of freedom (side slip and yaw) dynamic handling equations. Thus he gets an indication of the magnitude of the handling problems, as well as some guide to the sensitivity of the car-to-control inputs.

Later in the program, the suspension designer checks the handling of the car with the more complex three degrees of freedom (side slip, yaw, and roll) equations.

He studies the general suspension arrangement available in the space allotted, however, at the same time he is making his preliminary handling studies.

At this time, several alternate designs are considered. Complete calculations on each alternative are made on a computer in conjunction with the layout work. With these studies under way, limitations become apparent. So, negotiations with other chassis groups and the stylists may be necessary to provide room to incorporate adequate roll steer, control-arm lengths, knuckle spans, etc.

Once the geometry is finalized, the suspension designer proceeds to work within the confines of the space reserved for the suspension. (At this point, the advance design work is completed and the production components work proceeds. Each of the pieces is carefully analyzed as to stress, manufacturability, cost, durability, and appearance.)

The suspension designer is now ready to attack the many variables involved in making the actual design.

Camber

Selection of the camber pattern, for example, is influenced by a remarkable number of factors. The outcome of the necessary compromises can be materially affected by factors seemingly unrelated to suspension . . . factors such as engine layout, body width, styling freedom, corrosion protection, and parking-brake-pedal location.

Four basic variables affect camber: (1) control arm length ratio (ratio of upper control arm to lower control arm); (2) knuckle length ratio (ratio of knuckle length to lower control arm); (3) control arm starting angle; and (4) control arm absolute length.

The relative effect of the variables is shown in Fig. 1. Note that the variation of the upper control arm produces a much more dramatic effect in camber change than knuckle length.

Fig. 2 is a graph of camber angle versus jounce for a 1961 Plymouth and is plotted in the normal coordinate system of camber angle versus travel. This figure also indicates the range of camber patterns that can normally be expected. Note that on the Valiant, which has smaller tires, brakes, and lower unsprung weight, it is possible to accept a more sharply changing camber pattern than on the larger Plymouth.

In a handling situation, it seems more reasonable to plot the camber angle versus car roll angle and to determine camber relative to the ground rather than the car, since it is the camber thrust that

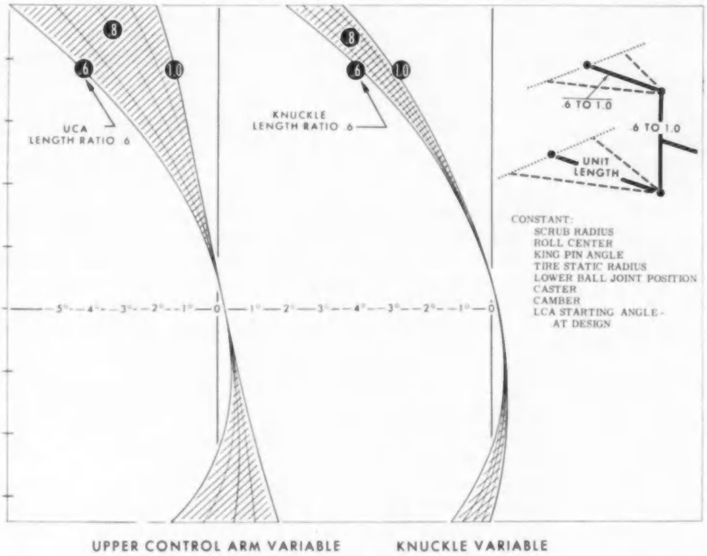


Fig. 1 — Relative effect of variables involved in selection of camber pattern.

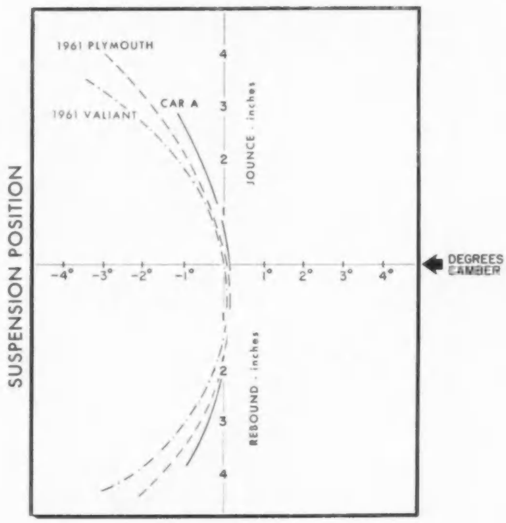


Fig. 2 — Graph of camber angle versus jounce for 1961 Plymouth and Valiant. Indicated also is the range of camber patterns normally to be expected.

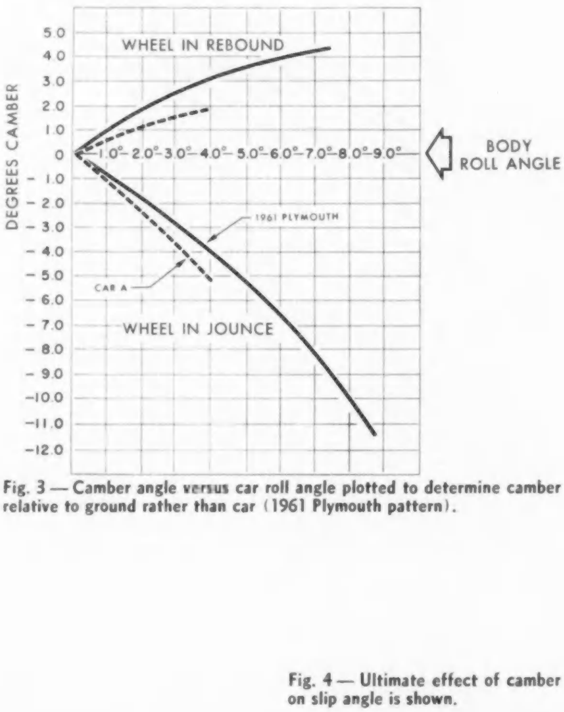


Fig. 3 — Camber angle versus car roll angle plotted to determine camber relative to ground rather than car (1961 Plymouth pattern).

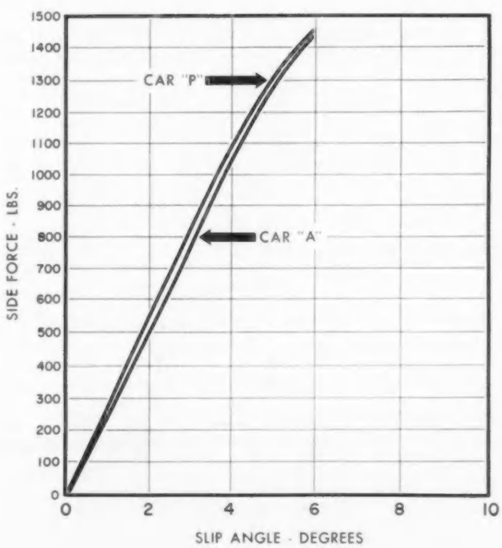


Fig. 4 — Ultimate effect of camber on slip angle is shown.

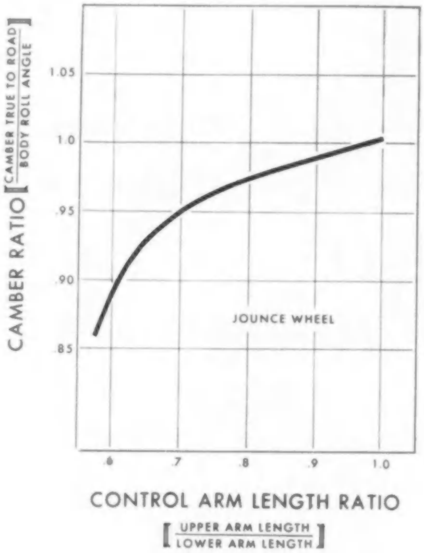


Fig. 5 — Camber angle plotted as degrees of tire angle to the ground per degree of body roll compared to control arm ratio.

designing front suspensions

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needs to be determined. Fig. 3 is the same 1961 Plymouth camber pattern plotted in this manner. It is interesting to note, when comparisons are made (Fig. 2) between the camber pattern of our 1961 Plymouth, which is considered rather "sharp," and another car with a much "softer" camber curve, that there is actually a very small difference in the camber angle relative to the road.

Fig. 4 indicates the ultimate effect of camber on front wheel slip angle. Car "P" is a 1961 Plymouth; Car "A" is the same car except it has the "softer" camber curve previously mentioned.

Fig. 5 is a graph of camber angle plotted as degrees of tire angle to the ground per degree of body roll compared to control arm ratio. This chart shows the "fast breaking" characteristics in the 0.7 in. length ratio area. This is why engine or frame designers may get a violent reaction from the

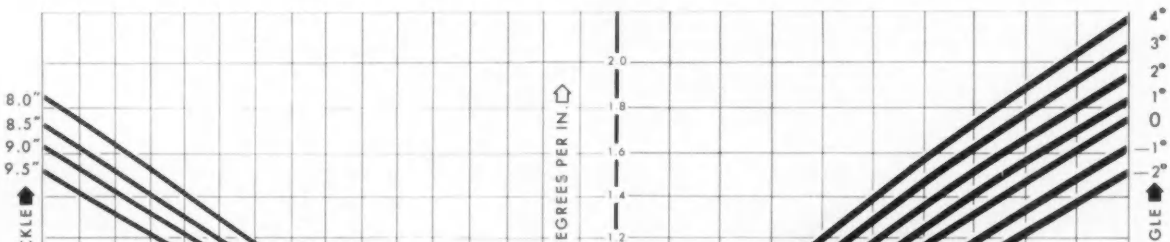

Fig. 6 — Chart of dive control alignment.

suspension group when it is suggested that the upper control arm be shortened, "Oh, just ⅜ of an inch," since it produces such a large change in the camber pattern.

Many other factors affect the choice of a camber pattern besides the cornering power aspects. In some cases, the camber pattern will need to be modified to allow a satisfactory match with the steering linkage that can be accommodated. Often, tie rods or centerlink locations are severely restricted due to the position of other components in the car which cannot be simply moved. (For example, the torsion bars or engine location may require short tie-rods, and thus a rather sharply breaking camber pattern may be needed.)

Attitude control and caster change

Attitude control on front suspension during braking is required to prevent car pitching during deceleration. The general method of obtaining this attitude control is to incline the upper and lower control arms so that the instantaneous center of rotation of the steering knuckle is behind and slightly below the center of the wheel, nearly on a line joining the contact patch of the tire to ground and the so called center of braking.

On most suspensions this procedure causes some change in caster angle as the tire moves through jounce and rebound. In general, this caster change ranges from 0.5 deg per in. to 1.7 deg per in. on common automobiles now in production. This caster change in itself seems to be undesirable. It increases the caster with load and causes the loaded tire to have an increase in caster during cornering. The rotational effect of the caster change reacts into the body due to the inertia of the parts rotated when the tire runs over a bump. However undesirable this caster is, it seems to be one of the compromises one must accept with most conventional types of antidive front suspension if the lower control arm cannot be placed at a high angle.

Determination of the location of the instant center to provide the necessary dive control is a rather simple analytical process but quite time consuming because of the number and complexity of the equations and factors involved. Since most cars now in production fall into the same general area of wheelbase, polar moment of inertia, and center of gravity height, it is possible to construct a simple alignment chart which is used to provide initial layout information and to make readily visible the effects of control arm included angle and knuckle length on caster change. The effects of caster change and lower control arm angle on attitude are also shown.

Fig. 6 is such a chart, which has been prepared for a car of the 110–120-in. wheelbase size, with the center of gravity of the sprung mass approximately 23 in. above ground.

This chart and the others like it for other ranges of car size are extremely useful and timesaving in determining from the attitude requirements the necessary control arm angles after various other design criteria have been set. Although it is admittedly a substantial over-simplification of the problem, its accuracy has been quite satisfactory. The general construction of this type of chart for use in a design area has much to recommend it, as nontechnically trained personnel can readily determine the necessary angles with a minimum amount of supervision.

Roll center

The selection of a roll center for a front suspension geometry is one of the basic decisions in design of suspension linkage. This decision must be made early in the selection of a linkage geometry and has a substantial effect on the other factors of the linkage design throughout the program.

In general, it is desirable to have as high a roll center as can be accommodated in order to minimize car body roll. However, this desire must be mitigated by the understanding that too high a roll center causes large scuff and the resulting high forces applied to the body. Selection of roll center height must also be based on the weight distribution of the car and the desired degree of roll stability. With a car, which for some reason is dynamically somewhat less stable than desirable and has a roll couple distribution such that the roll stiffness in the front is higher than in the rear, an increase in stability can be accomplished in some cases by lowering the front roll center.

Fig. 7 shows the roll center height versus wheel travel on a 1961 Plymouth, along with the roll center characteristic curves for a few other cars. A somewhat higher roll center at design with less downward slope to the curve in jounce seems de-

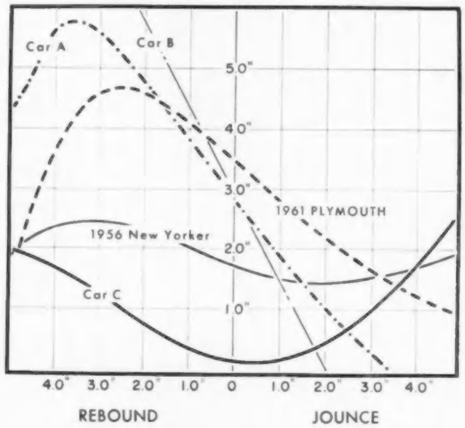

Fig. 7 — Roll center height versus wheel travel on 1961 Plymouth, together with roll center characteristic curves for several other cars.

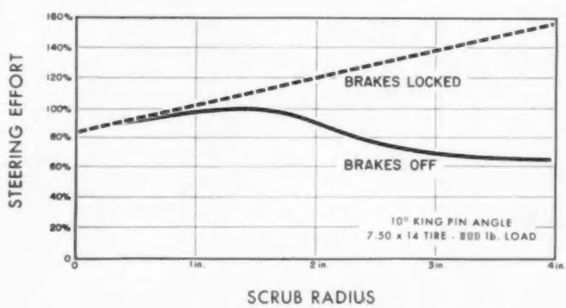

Fig. 8 — Increased scrub radius causes increased steering effort when the brakes are applied, as in parking with an automatic transmission.

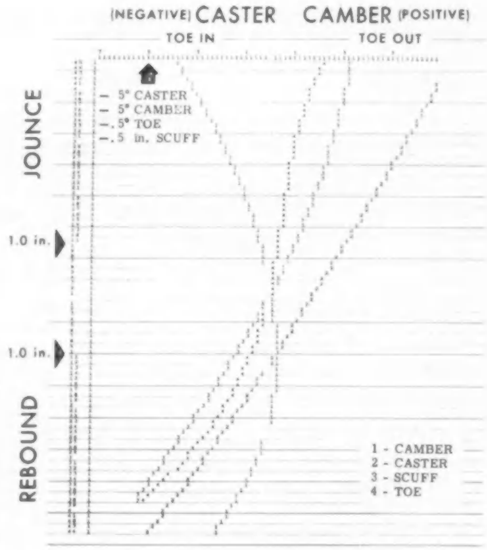

Fig. 9 — Castor-camber and toe-in curves indicating selection of 1961 Plymouth "best compromise" geometry.

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sirable to keep the roll center up on a heavily loaded car to reduce the roll angle, and reduce the "heavy feeling" of the car when loaded. A high slope of this curve produces a jacking effect and a peculiar roll situation which may cause some small bump undulating road disturbances and also could contribute to wind stability problems.

Scrub and kingpin angle

Scrub radius is the distance from the center of the tire patch to the intersection of the ground and the kingpin centerline. For some time it was considered ideal to have a zero scrub radius, but more careful study indicates that a moderate scrub radius is desirable.

Tests run on a car with variable kingpin angle and scrub radius indicated that a minimum desirable scrub radius exists. Decreasing scrub radius below this point increases steering effort, because it

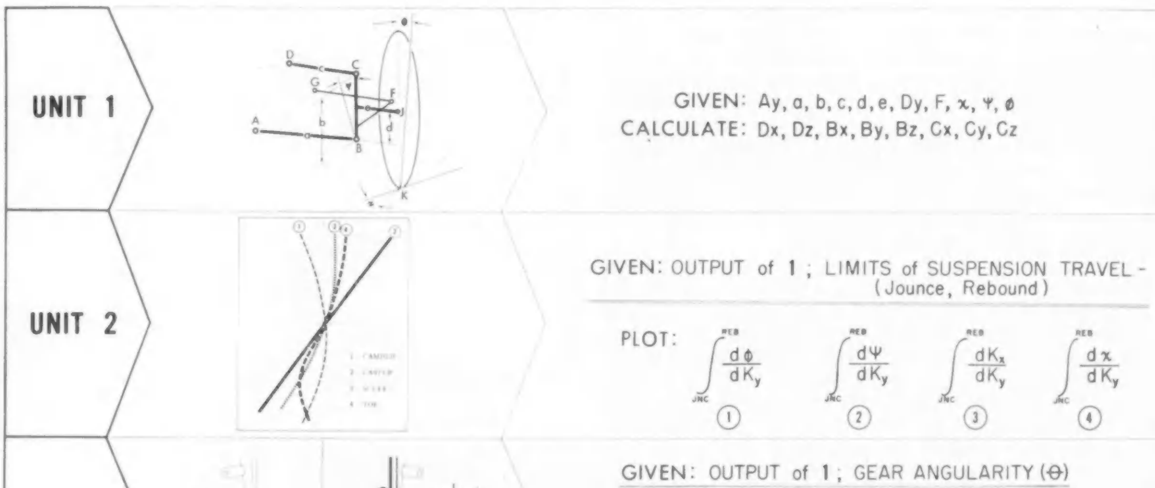

Fig. 10 — Chrysler computer program for analysis to determine properties of the linkage.

appears that the tire no longer can roll as it turns (when the car is standing still). Increased scrub radius causes increased steering effort when the brakes are applied as in parking with an automatic transmission. (Fig. 8)

On the Valiant suspension, this scrub radius is reduced to about 2 in. It is, of course, easily reduced with an increase in kingpin angle. The Valiant kingpin angle is 7½ deg. It would seem desirable to keep the kingpin angle about this range. When the kingpin angle increases, the steering effort and parking increases due to the necessity of raising the car with the steering linkage. A reduction in kingpin angle reduces the static stability and steering returnability of the car. Kingpin angle causes camber increase (change toward positive) on the jounce wheel in cornering.

Relationship of front suspension and ride

Generally, car ride (that is, basic car ride) is determined for the most part by the primary ride frequency of the car. Chrysler has attempted to obtain as low a ride frequency as possible, consistent with good handling. This has resulted in primary ride frequency in the order of 60–80 cycles per min. Our front ride frequency is somewhat higher on the lighter cars without sway bars. This has been necessitated to maintain satisfactory car handling and roll stiffness and roll couple distribution, front to rear. This increase in ride frequency has been partially offset by the gains from eliminating ride harshness and noise transmitted through the sway bar. As a supplementary benefit, the price of a sway bar has been saved.

The computer programs that we have developed are of substantial help in developing the ride rates and the ride rate change over the suspension travel. It seems most desirable to have a rate buildup in jounce and reduction in rebound. This is quite nicely accomplished with the well-known bar type of suspension, when added with what we call linkage rate or linkage effects.

The harshness problem is, of course, a primary ride problem. Empirical data and ride evaluation indicate that increase in fore and aft flexibility of the front suspensions results in the decrease of ride harshness. This fact was a major consideration in selection of the type of front suspension lower control arm on Chrysler's "Torsion Aire" suspension in 1957. A front strut bushing allows the fore and aft flexibility that is required and the wide spans provide sufficient torsional rigidity of the suspension to keep the brake chatter frequency in the less troubesome range.

In general, we feel that a reduction in caster change by lowering inertia forces is desirable. A reduction in scuff seems to be desirable by reducing the lateral forces induced in bump and a reduction in camber and toe change seems to be desirable to reduce the gyroscopic forces applied to the body. When you look at these all put together, you conclude that the suspension shouldn't move as it goes over a bump. This seems to place us on the horns of a dilemma and the solution, like most engineering problems, requires a compromise. The caster/

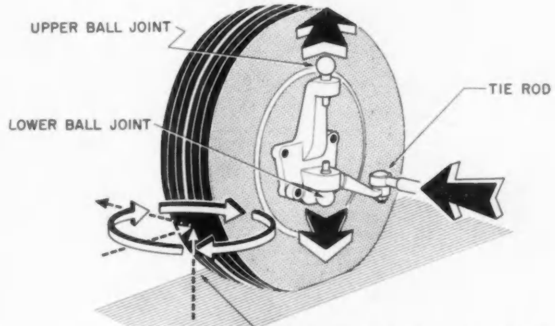

Fig. 11 — Forces of steering knuckle.

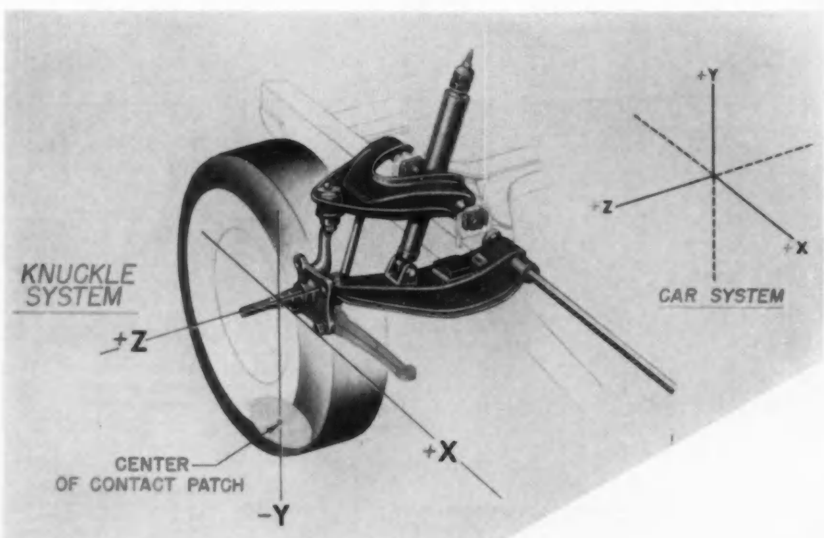

Fig. 12 — Coordinate system to define precisely the point of application of forces.

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camber, toe and scrub curves which have been presented indicate our selection of what we feel is the best compromise. (Fig. 9)

The noise problem is an integral part of ride. It is extremely difficult to separate noise in a car from the ride in a car when making an evaluation.

Linkage geometry

Front suspension geometry layout can be analyzed with a digital computer program which determines the properties of the linkage. The Chrysler Corp. suspension geometry program has four units: The first unit calculates the precise location of the suspension pivots given, the true lengths of the arms, knuckles, etc.; the second unit uses the suspension pivot locations and control arm lengths from the first unit to determine curves of caster/camber, scrub, and toe change. The third unit calculates steering linkage ratio to predict steering effort. The fourth unit determines linkage sensitivity and provides a sensitivity index for each pivot location and is very useful for determining production tolerances (Fig. 10).

Force analysis

A computer program calculates the forces on the front suspension when forces are applied anywhere to the tire.

Since the suspension and steering geometry had

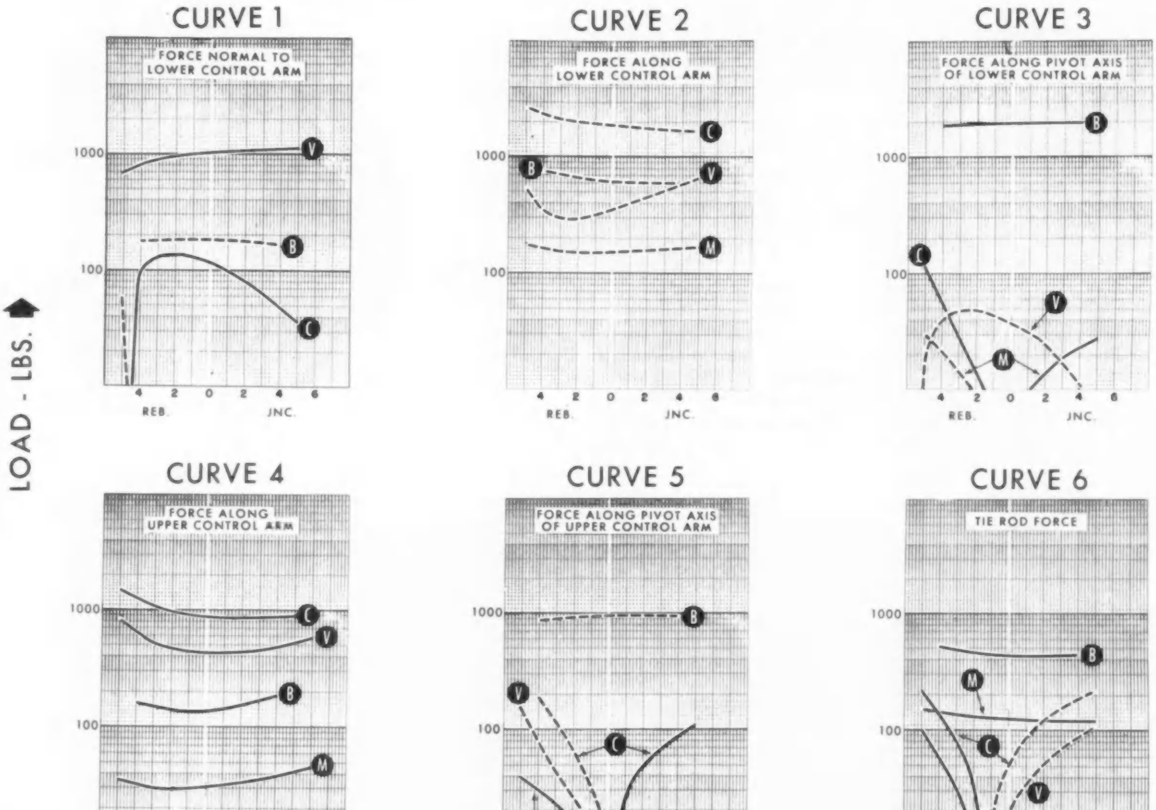


Fig. 13 — Calculation of specific load components throughout full range of suspension positions.

LEGEND

LINE V = 1000 LBS. - VERTICAL
LINE B = 1000 LBS. - BRAKING
LINE C = 1000 LBS. - LATERAL
LINE M = 1000 IN. LBS. - TORQUE
---- = NEGATIVE VALUES

previously been solved, the first step in the procedure was to write the three dimensional vector equations. In the suspension the spring force is applied to the lower control arm. Two assumptions were made to simplify the problem; namely, bushing rates and rebound bumper loads were neglected. This meant that the upper ball joints have no force component perpendicular to the plane of the upper control arm.

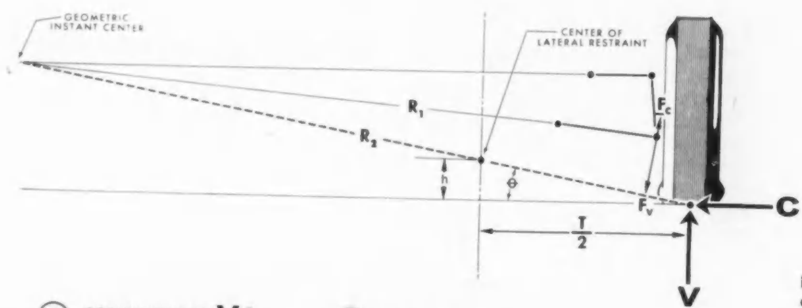
In addition to a force on the upper ball joint in the plane of the upper control arm, a second force acts on the end of the steering knuckle arm in the direction of the tie-rod, and a third force of unknown direction and magnitude is present in the lower ball joint (see Fig. 11). This makes a total of six unknowns, for convenience designated as follows:

Forces acting on the upper ball joint	(1) Along the upper control arm. (2) Parallel to the upper control arm pivot axis.
Force acting on the steering knuckle arm	(3) In the direction of the tie rod.
Forces acting on the lower ball joint	(4) Along the lower control arm. (5) Parallel to the lower control arm pivot axis. (6) Normal to the plane of the lower control arm.

At this point it becomes necessary to decide how the forces will be applied to the tire. Provision was made to apply a general force to any point on the tire as well as a general moment.

The problem is not quite this simple, however, since it is necessary to define very precisely how the force is to be applied to the tire. This requires consideration of two separate coordinate systems; one to describe the direction of the applied force and a second to describe the point of application of the force. The direction of the applied force, in our case, was chosen to conform to the car coordinate axes. This meant that each of our general forces could be defined by three components; for example, 1000 lb vertically downward, 500 lb rearward, and 200 lb to the left.

To define the point of application of the forces



(1) CONSIDERING **V**:

$$F_v = V\cos\theta\left(\frac{R_1}{R_2}\right)$$

(2) CONSIDERING **C**:

$$F_c = C\sin\theta\left(\frac{R_1}{R_2}\right)$$

(3) IF V = C:

$$\frac{F_c}{F_v} = \frac{C\sin\theta\left(\frac{R_1}{R_2}\right)}{V\cos\theta\left(\frac{R_1}{R_2}\right)} = \frac{\sin\theta}{\cos\theta} = \tan\theta$$

(4)

$$h = \frac{T}{2}\tan\theta = \left(\frac{T}{2}\right)\left(\frac{F_c}{F_v}\right)$$

Fig. 14 — Development of "roll center" calculation showing instantaneous center of lateral restraint.

Fig. 15 — Calculation of front suspension position for any deceleration rate to determine "antidive" merit.

designing front suspensions

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precisely, a new coordinate system was set up. This coordinate system is oriented to the wheel spindle by choosing the origin as the center of the wheel and orienting the Z axis outward along the wheel spindle. Up to this point the X and Y axes have not been defined, but it was felt that if forces could be applied in all cases in relation to the lowest point on the tire, we would have a very specific method of describing the location of input forces. This was done by specifying that the negative Y axis will always pass through the lowest point on the tire (see Fig. 12).

We now have our problem completely defined and at this point it can be programmed into the computer. The mechanics of this procedure vary with different machines; however, it is possibly worthy of note that our specific problem required more than 2000 memory units.

After programming and checking the problem was completed, many specific force problems were solved. However, the most useful type of problem was found to be the general survey type of problem where specific load components were calculated throughout the full range of suspension positions. For convenience it was agreed that separate 1000 lb vertical, braking, and cornering forces would be applied. Once this problem was worked by the computer, larger or smaller forces were evaluated by ratio and a combination of forces was made by ratio and algebraic addition of the output forces. A series of six curves (Fig. 13) is shown to indicate the results of this calculation on a 1961 Plymouth.

Possibly the most interesting curve in this series is curve 1. This curve shows forces normal to the plane of the lower control arm (or effective spring force) for suspension input forces of 1000 lb vertically upward, 1000 lb braking and 1000 lb left cornering. With this curve, much information can be gleaned regarding the basic suspension characteristics. The variation of spring force throughout suspension travel for a 1000 lb vertical tire force indicates the effective linkage rate; a 1000 lb braking force indicates the relative dive control; and a 1000 lb cornering force indicates the relative position of the "roll center." The development of this "roll center" calculation is shown in Fig. 14.

Since this problem considers only the suspension geometry, a direct comparison of various suspensions can be made. We have developed the term "suspension antidive merit" to describe the potential antidive characteristics of various suspensions. When this is coupled with the car parameters, such as wheelbase, center of gravity height, brake distribution ratio, static deflection and weight distribution, it is easily possible to calculate front suspension position for any deceleration rate (Fig. 15).

To Order Paper No. 295B . . .
from which material for this article was drawn, see p. 6.

Tips from Chrysler on design and use of

Aluminum threaded fasteners with die-cast

From paper by

E. G. Moeller, W. L. Weertman, and H. E. Eriksen

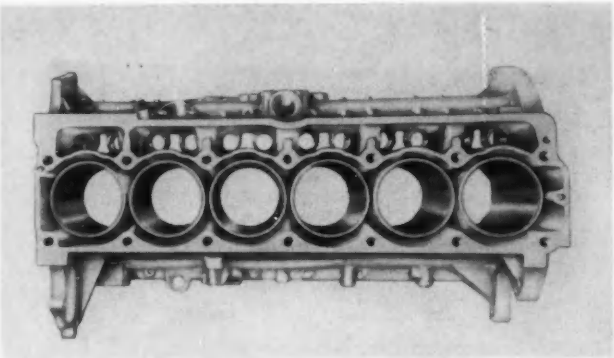
Chrysler Corp.

CHRYSLER has established some specific data on what can and can't be done successfully when designing aluminum threaded fasteners for use with die-cast aluminum parts. Laboratory work has been going on for several years. Its results are finding current application in the die-cast aluminum cylinder block and other areas of Chrysler's new slant-six engine family.

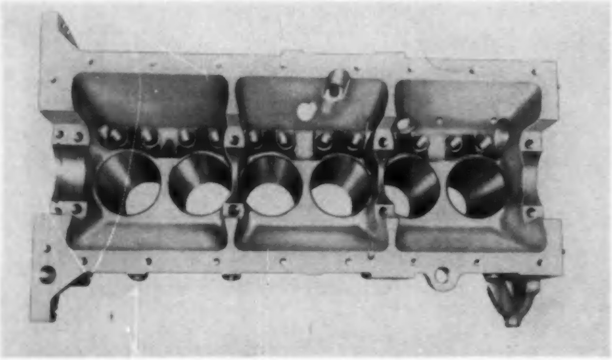
The strength of an aluminum boss thread associated with heavily loaded high-tensile-steel capscrews, Chrysler's researchers find, can be made to exceed the strength of the shank of the screw if the threaded engagement in aluminum is made 2½ times as long as the screw-thread diameter.

Bearing areas for minimum permanent distortion should be designed using 10,000-psi yield strength for die-cast aluminum.

Useful data also were developed on the problem of the considerable hoop stress developed by the reaction of screw-thread angles. Where space is limited and where maximum loads of high-tensile screws are utilized, buttress-type threads are sometimes needed. But always, the screw boss must have enough hoop strength to withstand the lateral



Top (left) and bottom (right) views of die-cast aluminum cylinder block in which aluminum threaded fasteners are used. (Cylinder block is used in Chrysler Corp.'s recently introduced slant-six engine family.)



aluminum parts

component of load applied by the screw thread. . . . Here again, the yield point of die-cast aluminum of 10,000–15,000 psi determines the size of boss needed for the application.

It was also found that there is a greater tendency to cross thread a fastener during assembly with the aluminum threaded fasteners than with the cast-iron fasteners. This is due to the lower hardness of aluminum.

Also, there is a greater tendency toward galling, which may result in failure of the screw threads. So, there is a slightly greater frequency of screw thread failure in aluminum die castings than in cast iron. But several types of inserts are available that provide convenient and effective means of making repairs in tapped holes when necessary.

Special problems

With these facts in mind, Chrysler engineers found, it isn't hard to design the die-cast aluminum component so that the threaded hole and surrounding boss are stronger than the fastener in most applications.

The cylinder head and the main bearing caps fasteners, however, posed some special problems in the new Chrysler slant-six.

The cylinder-head-to-block capscrew in this cylinder head is UNC 7/16–14. It is torqued to 65 ft-lb and produces an axial load of about 10,000 lb. Except for a longer thread engagement, this screw is identical in size and torque applied to the one used in the previous cast-iron cylinder block. A 1-in. diameter boss around the tapped hole provides adequate bearing strength. The load is transferred to the water jacket wall by generous blending of the screw boss into adjoining surfaces.

The main bearing screw load has definite limitations in aluminum blocks. Reason: It must prevent relative dynamic movement at the bearing cap parting face and yet not overload the aluminum boss supporting the bearing cap structure.

The main bearing capscrew is a UNC ½–13 fastener. It is torqued to 50 ft-lb and produces an axial load of approximately 7500 lb. The applied load is limited in this application because the aluminum bearing area under the upper bearing cap is about 0.9 sq in. — and yielding starts to occur at 60 ft-lb torque or 9000 lb axial load.

Excessive yielding of the aluminum must be avoided in this application, as it affects the bearing cap fit and alignment in the cylinder block. Extensive testing assures that a 7500 lb screw load provides excellent bearing and cap durability with an acceptable factor of safety against variations in screw load due to assembly conditions.

To Order Paper No. 307C . . .
from which material for this article was drawn, see p. 6.

Honeycomb excels for Mach 3 wing

Based on paper by

Jack C. Joanides, Stanley C. Mellin, and Leslie M. Lackman

Structures Section, North American Aviation, Inc.

WING	PH15-7 MO SANDWICH	INTEGRALLY STIFFENED SKIN		
		AM 355	ALL BETA TITANIUM	BERYLLIUM
SPARS	1500	2758	2422	1822
INSULATION PLUS RETAINER	0	1800	1800	1800
TOP & BOTTOM WING COVERS	9465	12712	10142	6421
TOTAL WING WEIGHT	10965	17270	14364	10043

Fig. 1 — Comparison of the weights of Mach 3.0 wings using honeycomb sandwich construction and stiffened skin construction points up the advantages of using honeycomb. The insulation requirements for the honeycomb wing are completely satisfied by adjusting the core thickness.

	LOADING		
	LOW	MEDIUM	HIGH
FACE THICKNESS	.006	.0195	.0573
CORE THICKNESS	.44	.85	.93
SPAR SPACING	14	17	15
SPAR WEB THICKNESS	t_w =.0119	t_w =.0247	t_w =.0340

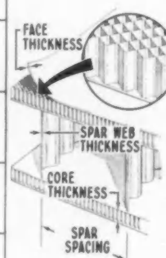


Fig. 2 — Honeycomb panel is designed to achieve the lightest wing while preventing failure due to general instability of the total panel or local failure of the facing sheets by intracell buckling or by wrinkling. The spar spacing was fixed throughout the wing in this study.

EXCELLENCE of the honeycomb-type structure is impressive, when compared with the stiffened skin type, for application in Mach 3.0 wing structures. Use of honeycomb in such a wing will provide a much lighter structure, compared to the integrally stiffened wing, for handling the loads encountered in flight at Mach 3.0.

This is a major conclusion to be drawn from recent studies made at North American Aviation. This study compares the weight of the wing plus insulation resulting from the use of PH15–7 Mo steel brazed honeycomb, to that resulting from the use of a stiffened skin design employing three different materials: AM-355 steel, all-beta titanium alloy, or beryllium. The results obtained are tabulated in Fig. 1, where it is seen that the honeycomb design yields a heavier wing than the stiffened skin type using beryllium, but it is far lighter than the other two wings considered.

The greater spar weights calculated for the stiffened wing, as shown in Fig. 1, reflect the closer spar spacing required for these wings. This is due to the low moment of inertia of the stiffened skin construction, which renders it more sensitive to bending loads.

The need for sophisticated stiffening systems, such as the two considered in this study, came with the advent of Mach 3.0 aircraft. Where the low density aluminum was formerly used, the more stringent conditions encountered with these aircraft led to the consideration of such materials as steel and titanium. Unless some means of stiffening is employed the strength/weight ratio of aluminum cannot be matched by these materials. As an example, for the same structural width and for equal weight, the ratio of elastic buckling stress of steel to aluminum is approximately 1 to 3.

For this study the aircraft was assumed to have a delta wing with an aspect ratio of less than two, and to cruise at Mach 3.0 and 70,000 ft. Since the type of wing chosen is subjected to significant chordwise bending moments, a realistic optimization of the wing must include these, along with the spanwise loads usually considered.

Aerodynamic heating requires that provisions be included to eliminate, within practical limits, fuel vaporization. Two methods available to limit fuel vaporization are: the use of insulation in the wing to reduce fuel temperature rise or wing pressuriza-

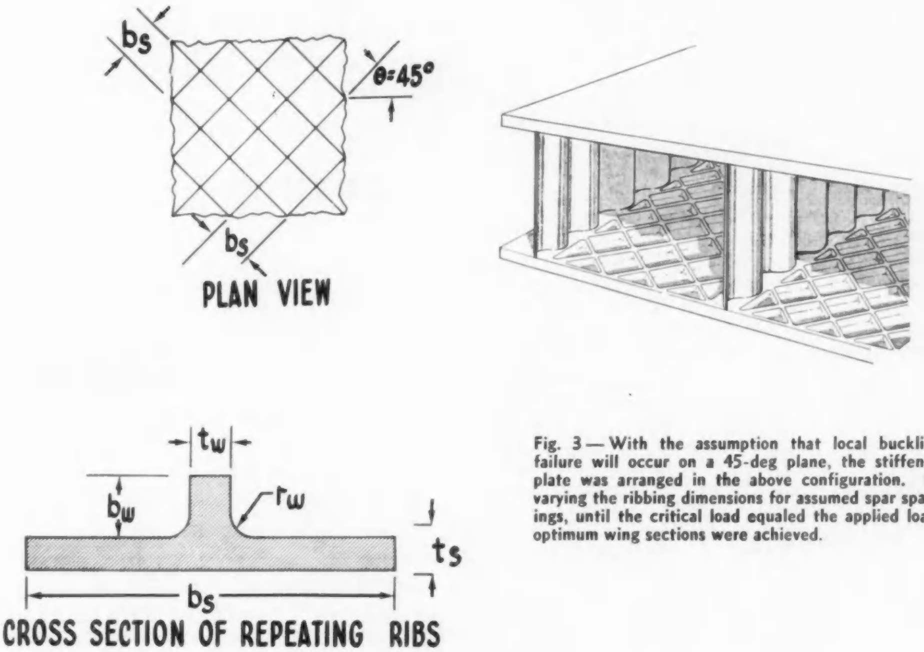


Fig. 3 — With the assumption that local buckling failure will occur on a 45-deg plane, the stiffened plate was arranged in the above configuration. By varying the ribbing dimensions for assumed spar spacings, until the critical load equaled the applied load, optimum wing sections were achieved.

MATERIAL / LOADING	AM355 STEEL	ALL BETA TITANIUM	BERYLLIUM
LOW	.40 .020 1.00 .018	.55 .027 1.83 .033	.38 .026 1.91 .046
MEDIUM	.55 .055 1.38 .058	1.10 .073 3.66 .102	.26 .052 2.62 .220
HIGH	.49 .062 1.23 .073	1.33 .088 4.42 .139	.83 .118 4.13 .279

Fig. 4 — Dimensions of the stiffened skin for different load conditions, at a typical wing station, are shown. For this study the wing was broken down into 53 stations.

Honeycomb excels for Mach 3 wing

. . . continued

tion to raise the boiling point of the fuel. These two methods can be used simultaneously in varying combinations. Thus, the low tolerance exhibited by the integrally stiffened skin for bending loads indicates that a lower pressure would be more desirable for such a wing, at the expense of adding weight in the form of insulation. Not only does the honeycomb design more readily meet the strength requirements but, with its relatively low thermal conductance, insulation requirements are reduced. In fact, for little additional weight, insulation requirements can be completely satisfied by increasing core depth.

The physical appearance of the two structural types is shown in Figs. 2 and 3. In both cases the corrugated panel was chosen as the optimum spar web. For all cases considered the skin was sized for optimum thickness by asuming various spar spacings and including the effect of the spar-to-skin attachments. For practical reasons a minimum gage of 0.01 in. was imposed on the corrugated panels.

The stiffened plate was analyzed by varying the dimensions of the ribbing (Fig. 3) for different values of spar spacing (spacings of 6, 9, 12, 15, and 18 in. were used) until a configuration was reached in which the applied load caused the maximum allowable stress. In programming this analysis, the ratio of rib height to rib spacing (b_w/b_s in Fig. 3) varied from 0.05 to 1.50. Study of 53 stations on the wing, performed in this manner, provided the information necessary to calculate the optimum weight of each of the three wings considered. The results of these calculations are illustrated in Fig. 4 where the optimum cross-sections at a typical wing station are shown for different loads.

The honeycomb panel optimization is designed to achieve the lightest wing while preventing failure due to general instability of the total panel or local failure of the facing sheets. Facing sheet thickness requirements were computed by assuming the wing to have a certain fixed spar spacing and sizing the core depth for this configuration. Twenty wings, having spar spacings of from 7.5 to 30 in. and core depths varying from 3/8 to 1½ in., were studied. For each of the fixed spar spacings considered, an optimum core thickness was found which gave the thinnest panel facing. The spar spacing giving the lowest optimum facing thickness was then selected as the best configuration. Results showed that increasing the core depth for the sake of adding insulation did not cause an intolerable departure from the optimum conditions. Typical cross-section dimensions of the honeycomb panel, for different loadings, are shown in Fig. 2.

In this study no attempt was made to completely optimize the insulation requirements on the wing tanks.

To Order Paper No. 233D . . .
from which material for this article was drawn, see p. 6.

Starting turbojets

Based on paper by

F. R. Cordon and D. J. Hucker
Sundstrand Aviation

TURBOJET engine starting may be done electrically, in the future, by using the a-c generator as a motor, to drive the engine through the constant-speed drive. The hydrostatic transmission of the constant-speed drive can be arranged to provide the necessary coupling characteristics and to program the torque output to meet turbine starting requirements. Existing aircraft a-c generators have the characteristics to function as a starter motor, when operated with the hydrostatic torque multiplier, so they may be used for such a system.

The primary objective of the starter-drive system is to yield an automatic integrated starting and generating system, which eliminates the need of a separate engine starter. Weight savings of 50 lb per engine may be realized by substituting this system for existing generator and starting systems.

In doing this, no compromise is made with power quality or conversion efficiency in the generating mode. The generating performance of this scheme is the same as for a conventional hydrostatic constant-speed drive used for a 400-cps aircraft system. The steady state frequency control, without precise trim, is ±2 cps. Precise frequency control can be added, if required, to control to ±0.1 cps. Full load transient deviation is within ±5% (20 cps).

It is possible to adapt an existing electrical system to accommodate the staring function. A single initiating control switch controls the starting sequence automatically and the transfer to the generating mode.

Drive unit description

The job of the constant-speed drive during starting is to allow the generator to accelerate with minimum connected load, as an induction motor, to

with generator drive

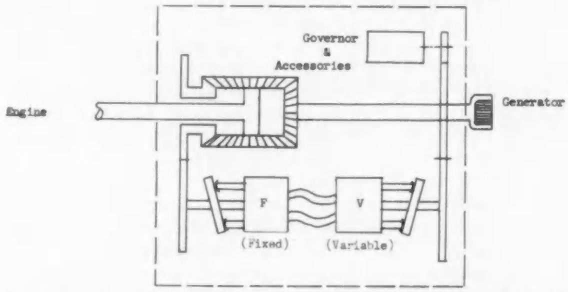


Fig. 1 — Transmission schematic of the starter-drive unit. The fixed hydraulic unit has two positions, zero stroke for induction motor starting and full stroke for all other phases of operation. The variable unit wobbler is controlled by the flyball governor during the generator phase and by a pressure regulator during the cranking phase of operation.

synchronous speed. The generator must then run at constant speed as a synchronous motor to deliver power to the engine. Therefore, to initiate cranking, the transmission must convert generator speed to zero speed at the engine. Once synchronous speed is reached, the drive unit must program the torque delivered to the engine in such a manner as to achieve a start that will not cause engine overheat or take too long to complete.

A schematic drawing of the arrangement of components of the starter-drive unit which will provide the desired characteristics is shown in Fig. 1. The transmission consists essentially of a differential gear train and two axial hydraulic units. One of these is fully variable, the other has a two-position wobbler which provides zero stroke for the induction motor phase and full stroke for all other phases of operation.

Considering first the configuration used for the induction motor phase of operation, both units are at zero stroke (displacement) and there is no flow between the two units. Since for any positive displacement hydraulic unit, the torque developed is a function of the product of displacement and pressure, no torque is developed in this configuration and the generator is free to rotate independent of the engine. The only retarding loads are due to windage and inertia of the cylinder blocks and gearing and these are not great enough to seriously affect induction motor starting.

Once synchronous speed is reached, and the synchronous motor phase of operation is to begin, both

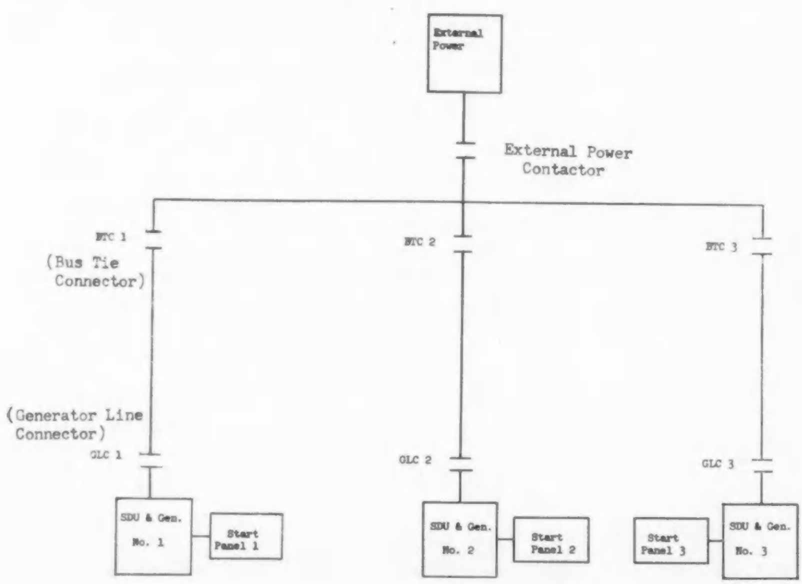


Fig. 2 — Block diagram of a multigenerator bus configuration. Existing electrical systems can be used for this system in order to achieve automatic starts from external power and for cross-starting.

units are placed in the full stroke position. However, as the intake of one is equal to the discharge of tne other, no pressure, and therefore no torque, is developed. At the same time the generator is placed in the synchronous motor phase of operation by a governor signal to the electrical controls. All that is necessary to start transmitting torque is the development of pressure, and this is achieved by reducing the stroke of the variable unit. Control of the variable unit is transferred from the flyball governor to a pressure regulator for programming torque. Since the fixed unit displacement is constant, torque is proportional to pressure, which in turn is dependent upon the displacement of the variable unit. The regulator now gradually reduces the stroke of the variable unit to build up working pressure. During the initial cranking of the engine, application of constant torque is required, so the pressure regulator controls the variable unit, relative to the speed of the fixed unit, to maintain constant pressure.

After engine light-off the engine turbine develops a continuously increasing accelerating torque. This allows the cranking torque to be reduced to relieve the generator of load. Since the wobbler position of the variable unit is a direct indication of engine speed, it is sensed when the engine has accelerated to approximately light-off and a bias is applied to the torque-speed schedule. From this point to starter cutoff, the pressure, and hence the torque are reduced linearly with increasing speed at a rate similar to the torque buildup of the engine.

When the engine idling speed is reached, as sensed by wobbler position, the pressure regulator is deactivated and control of the variable unit is transferred to the flyball governor to provide normal generator speed control.

In the constant-speed drive mode of operation, as in the starting mode, the displacement of the variable unit is controlled; but here it is done to match the torque (pressure) requirement to maintain constant speed despite varying engine input speed or generator load.

For certain engine servicing operations it is desirable to be able to crank the engine without starting it. A reduced hydraulic pressure can be selected which will produce a lower torque level than for starting, but sufficient to motor the engine at light-off speed. This will require considerably lower electrical load on the generator, permitting prolonged motoring if desired.

System considerations

The starting and generating functions can be controlled with one *on-off* switch per engine. During the generating mode of operation, existing regulators, exciters, and control panels can be used to control and protect the generator. The control characteristics of the starter-drive unit (SDU) are similar enough, in the generating mode, to a conventional constant-speed drive, that existing governing system components can be used with only minor adjustments.

In addition to the normal generating system equipment, controls are necessary to program the automatic starting function. These controls must program the induction motor start, perform the transition to synchronous motor operation, control the power factor of the synchronous motor during its loading as programmed by the starter drive, and then change the machine to a synchronous generator supplying power to the load bus. Precautions must also be taken during the induction motor mode of operation to protect against the high induced voltage in the field winding.

Fig. 2 shows a block diagram of a typical multi-generator bus configuration. When the external power switch is turned on, this system would close the external power contacter and all bus tie contacters, supplying power to all load buses. This allows warmup of certain electronic gear before the engines are started. Now if a starter-drive control switch is turned to the *on* position, closing a generator line connector, that generator accelerates as an induction motor, automatically becomes synchronous, and accelerates the aircraft engine to idle speed. At this point its bus tie contactor is opened in response to a signal from the SDU. This generator is then capable of supplying electrical power to its loads. This procedure involves no power interruption and no requirement to operate as a generator sharing load with the external power source. The other generators could be started in a like manner until all the generators were supplying electrical power to their associated loads. When the external power connector is opened, one bus tie connector would be automatically closed. The automatic paralleling controls on the remaining machines then operate to place them all on the bus.

On a cross-start, one engine is started from external power, or by some auxiliary means such as a cartridge starter, and the generator on this engine is used to start the other engines. If the original start is from external power, as soon as this generator is supplying power to its own loads the external power switch is turned to the *off* position. This opens the external power contactor and closes all bus tie contactors so that the machine that is running supplies all aircraft loads. The remaining engines can be started one at a time from power supplied by this generator. This is done just like a start from external power except that there is no need to open the bus tie contactor at engine idle speed. The two systems will remain in parallel throughout the starting and generating cycles. A three- or four-generator system operates in a similar manner.

On shutdown, when the engine speed drops below the idle point, the generator line contactor is opened by the engine pad speed signal from the SDU, however the bus tie contactor is still closed, keeping the loads energized from the remaining generators. When the last generator is shut down, the external power contactor is automatically closed, causing a momentary interruption of power to the load.

To Order Paper No. S268 . . .
from which material for this article was drawn, see p. 6.

Hydraulic fluid particle growth halted

▸ **Elimination of viscosity improvers and small particles cuts the growth of large agglomerated contamination particles.**

Based on presentation by

Thomas N. Deane

Bray Oil Co.

(To Subcommittee A-6D, Missile Fluid Power Systems)

CONTAMINATION particle growth in hydraulic fluids comes from the agglomeration of small particles, studies at Bray Oil Co show. The growth can be checked by filtering out the normally acceptable size particles and restricting additives, such as viscosity improver methacrylate, that cause adhesion between particles.

The search for the cause and cure of particles that grow in a sealed can started when the whole lid was removed from a can of hydraulic fluid (MIL-H-5606) at an Air Force base (usually, a hole is punched in the top and the fluid poured as from a beer can). At the bottom were 50–200 micron particles, even though the fluid had been passed through a 10 micron filter before packaging.

Proof of agglomeration

Several tests all lead to the conclusion that large contamination particles are formed from small ones, rather than by some other mechanism.

1. Vibration accelerates the rate of growth of large particles. This additional energy increases the force with which particles strike each other and therefore the probability of their sticking together.
2. Large particles of precipitate (50–200 microns) decompose when disturbed.
3. The precipitate has been redispersed by agitation, the oil refiltered and repackaged, and after further storage, the precipitate has reformed.
4. Particle growth can be synthetically induced in 5606 oil, but not in oils containing polar rust preventive agents or oils that do not contain methacrylate viscosity-temperature improvers.

The mechanism for contaminant agglomeration is hypothesized as involving the adhesive forces resulting from chemically adsorbed films of polymer, bonded by the polarity of free acid residue. The key to this conclusion is in item (4) above, and the reasoning runs:

(a) The acrylic polymer is formed by polymerizing alkylmethacrylates, using the reactive double bond to effect the linkage. The ester groups then appear as side chains. However, some free acid residues occur along the chain. These lend a surface active property to the polymer. It tends to "wet" or plate out on surfaces just as fatty acids do. However, because of the resinous nature of the balance of the molecule, it fails to impart the properties of dispensency and oiliness characteristic of conventional fatty acids and their soaps; instead, the deposited polymer film acts as an adhesive. Such an adhesive film could explain the phenomenon of particle growth. In addition, it might also be the cause of the excessive drag and hysteresis experienced by highly finished, close fitting parts such as the spools of servo-valves.

(b) The polar additive used to impart corrosion protection to MIL-H-6083 (and incidentally, detergency to motor oils) is a much stronger surface active agent than are the fatty acids. Normally, it would be expected to displace fatty acid molecules from surfaces and be absorbed in their place. Such appears to be the case with adsorbed acrylic film.

Solution to agglomeration

Filtering out small particles that will later agglomerate is a twofold solution to particle growth.

First, if there are very few particles left after filtering, there is practically nothing to agglomerate.

Second, the reduction in number of particles is a strong force in preventing the mechanism of agglomeration from occurring. It is this fact that makes careful filtration practical even though perfect filtration isn't possible.

From the laws of physical chemistry, the rate of growth (or agglomeration) is proportional to the square of the concentration of particles. If better filtering cuts the particle count by a factor of 10, then the particle growth rate will drop by a factor of 100. Further, as particles do agglomerate, the particle concentration drops further, with a corresponding drop in growth rate. For example, if all particles were 5 microns and they combined to for half as many 10-micron particles, then the growth rate would drop by a factor of four.

The change in emphasis in this technique is to filter out particles that used to be considered acceptable, as well as the large "rocks" that have always been screened. In this way the growth rate will drop to such a low level that it may be considered as not taking place at all.

Dust injection tests reveal

relative merits of

Based on paper by

Glenn F. Hyde, Fred A. Robbins, and Paul R. Shepler

Koppers Co., Inc.

IRON RINGS in chromium-plated liners show less wear than bare rings in iron liners, and wear rates are reduced still further with chromium-plated rings in iron liners. There are also certain experimental rings which exhibit attractive wear characteristics in both iron and chromium-plated liners.

End clearance and liner wear as well as ring side and groove width wear in 48 hr for various ring-liner combinations are shown in Table 1. These measurements were obtained from accelerated wear tests conducted with a naturally aspirated, 6-cyl, Caterpillar D318 diesel engine.

Iron rings in iron liners

The dust injection test of 48 hr showed the average end clearance change of various types of iron top compression rings in iron liners to be 0.097 in. The cylinder liner wear for this same group of rings was 0.0045 in. as measured at the maximum wear points 31/32 in. below the top of the liner.

Iron rings in channel chromium-plated liners

Wear characteristics improve with chromium-plated liners. The average end clearance change of a group of iron rings is 0.048 in. in 48 hr, which is half the change experienced with iron liners (0.097 in.). The channel chromium liner wear for iron rings was 0.0015 in. in 48 hr, or approximately ⅓ the iron liner wear with the same type of rings.

Chromium-plated rings in iron liners

Inasmuch as chromium plating is customarily used as a facing material for top compression rings, much data have been collected on varying the base material of chromium rings in regard to its effect on face wear and side wear. It is also of interest to compare the ring and cylinder wear for chromium-plated rings in iron liners with that of iron rings in chromium liners.

The end clearance change for chromium-plated iron rings in iron liners was 0.011 in. in 48 hr. This compares with 0.048 in. for iron rings in chromium liners, and 0.097 in. for iron rings in iron liners. The 48-hr wear for iron cylinder liners with chromium-plated iron rings was 0.0012 in. diametral wear. This is somewhat less than the wear with iron rings in chromium liners (0.0015 in.) and approximately one-fourth the wear with iron rings in iron liners.

Since the chromium-plated iron rings in iron liners are, at present, the industry-accepted standard for small-bore diesel engines, the 0.011 in. end clearance and 0.0012 in. linear wear must be equaled or bettered for a ring-liner combination to be attractive.

Experimental rings in iron liners

A very small amount of ring wear occurs with flame-plated tungsten carbide, chromium carbide, aluminum oxide rings, and a special stainless steel. The end clearance change for the LW1 and LW5 tungsten carbide plated iron rings was 0.0005 in. in 48 hr. This is approximately one-twentieth the change of the chromium-plated iron rings in iron liners, about one-hundredth that of iron rings in chromium liners, and one-two hundredth that of iron rings in iron liners. These comparisons are shown in Table 1.

The value of the liner wear for these same tungsten carbide plated rings in iron liners is 0.0017 in. in 48 hr. This is 50% greater than the chromium-plated iron rings in iron liners, and very slightly greater than iron rings in chromium liners, but it is very much lower than iron rings in iron liners. These LW1 and LW5 tungsten carbide plated rings are being investigated for future use in elevated temperature conditions, and more tests in high output engines under typical operating conditions are being conducted.

Experimental rings in channel chromium-plated liners

Table 1 shows that an extremely low wear occurs with tool steel A in channel chromium liners. The end clearance changes are 0.003 and 0.005 in. respectively for the solid and grooved face designs.

ring-liner combinations

The corresponding chromium liner wears are 0.0033 and 0.0021 in. respectively, which is considerably higher than iron rings in chromium liners.

The 0.010-in. end clearance change of the special stainless steel ring is considerably less than that of iron rings in chromium liners. And the 0.0009-in. liner wear is somewhat below the 0.0015 in. of the iron rings in chromium liners. This stainless steel ring is attractive for both ring and liner wear and it is reasonably wear resistant when used in iron liners. Unfortunately, this material has borderline scuff resistance and must be altered to be attractive.

The end clearance changes of tool steel B — 0.021 in. in 48 hr — is about one-half that of irons in chromium liners, and it produces a chromium liner wear of 0.0014 in. or about the same as that of iron rings in chromium liners.

Nitrided steels have an end clearance change of 0.038 in. in 48 hr, which is better than iron rings in chromium liners. They produce a chromium liner wear of 0.0010 in. or about two-thirds that of iron rings. They do have some attraction because of ring and liner wear.

Ring side wear

Data indicate the ring side wear of top compression rings to be heavier in iron liners than in chromium liners (Table 1). The ring side wear of chromium-plated iron rings in iron liners falls between the two. Variation in side wear between different types of iron is doubtless influenced by the amount of rotary motion of the rings in the grooves, which is caused by small variations in the geometry of the motion of the piston in the cylinder.

Thirty observations have revealed that the side wear in the second 48-hr period is at least 50% greater than in the first one.

Certain experimental rings used with chromium liners had very low side wear. Tool steel A, in particular, had nearly zero side wear during either 48-hr period. The special stainless steel and nitrided steel were also low.

To Order Paper No. 259A . . .
from which material for this article was drawn, see p. 6.

Table 1

Top Ring and Liner Wear of Various Types of Rings in Iron and Chrome Liners

	Wear in 48 Hr			
	End Clearance	Ring Side	Groove Width	Liner[a]
Iron Rings in Iron Liners	0.097	0.0019	0.0013	0.0045
Iron Rings in Chrome Liners	0.048	0.0006	0.0009	0.0015
Chromium Plated Irons in Iron Liners	0.011	0.0012	0.0010	0.0012
LW1, LW5 Plated Irons in Iron Liners	0.0005	0.0017	0.0013	0.0017
LA2 Plated Irons in Iron Liners	0.0020	0.0053	0.0030	0.0031
Plasma WC Plated Irons in Iron Liners	0.0022	0.0028	0.0012	0.0033
LC1A Plated Irons in Iron Liners	0.0025	0.0025	0.0019	0.0022
Special S.S. in Iron Liners	0.011	0.0002	0.0005	0.0025[b]
Special S.S. in Chrome Liners	0.010	0.0002	0.0008	0.0009[b]
Tool Steel A in Chrome Liners	0.003	0.0000	0.0006	0.0033
Grooved Face T.S.A. in Chrome Liners	0.005	0.0001	0.0008	0.0021
Tool Steel B in Chrome Liners	0.021	0.0005	0.0011	0.0014
Steel C in Chrome Liners	0.030	0.0016	0.0010	0.0011
Nitrided Steel in Chrome Liners	0.038	0.0003	0.0004	0.0010
Nitrided Iron in Chrome Liners	0.055	0.0002	0.0004	0.0019

[a] At 31/32 in. below top of liner.
[b] Slightly incompatible.

From material drawn from an

SAE Metropolitan Section Paper

STOL demonstrated feasible

Based on paper by

F. N. Dickerman and C. F. Branson

Georgia Division, Lockheed Aircraft Corp.

COMPLETED initial phases of flight testing a C-130 Hercules cargo transport airplane with complete boundary layer control (BLC) have demonstrated minimum flight speeds below 50 mph and take-off and landing distances of about 600 ft at a gross weight of 100,000 lb. For comparison, the standard C-130 is capable of take-off and landing ground roll distances of approximately 1500 ft on unprepared fields.

This development, which combines the effectiveness of blown flaps with deflected slipstream to reduce take-off and landing speeds, has demonstrated the feasibility of achieving short take-off and landing (STOL) performance with a large cargo transport. The need for such a tactical aircraft was recognized by the U. S. Army and Air Force and was specified in General Operations Requirement (GOR) 130, which calls for the ability to carry 20,000 lb of cargo on a radius mission of 1000 nautical miles to a midpoint unprepared field with only 500 ft for ground roll available.

The development program has included design, construction, and flight testing of a test-bed BLC airplane. The design study of the test-bed included comprehensive wind-tunnel tests conducted on a one-tenth scale model of the BLC Hercules. A simple flight simulator, used primarily to test the stability and control of the test-bed BLC airplane, was constructed by connecting the C-130 full-scale control system mockup to an analog computer.

The minimum feasibility flight test program that was undertaken proved the BLC Hercules to be a practical STOL cargo transport. Further flight testing is also contemplated.

Aerodynamic considerations

To meet the requirements of GOR 130 it was necessary to achieve much higher maximum lift coefficients on the C-130 airplane. It was estimated that the required lift could be achieved by a combination of blowing boundary layer control and propeller slipstream deflection. (A suction-type system was also studied but did not prove comparable in performance to the blowing system.)

The maximum lift coefficient required for take-off is approximately 7.0 at a speed of 50 knots. The maximum lift due to blowing at 50 knots, with 60- and 90-deg flaps and 30-deg aileron droop, is 3.40. The additional lift at 50 knots, due to propeller slipstream, is 3.80. The total maximum lift is 7.20, slightly greater than that required to provide the desired take-off performance.

It was recognized early that the large thrust coefficients experienced on the BLC airplane would create stability and control difficulties. To provide satisfactory flying qualities — despite low stability levels — complete BLC is used. Not only is BLC applied to the flaps, but also to ailerons, rudder, and elevator. In addition, all surfaces have deflections approximately double those of the standard C-130 Hercules.

The highly effective controls make possible:

- Reduced minimum control speeds, with either a main propulsion engine or BLC engine inoperative, which are below the reduced lift-off and touchdown speeds.
- Reduced nose wheel lift-off speeds below the take-off speed.
- Reduced minimum flare speed below the landing touchdown speed.
- Stabilized low-speed flight using the control surfaces.

With reduced stability and airspeed, the response of the BLC airplane is slow compared to the human pilot reaction time. It was conceived that the pilot could conveniently fly the airplane in the same manner as a helicopter is flown or a car is driven.

Continuous small deflections would be required to provide the necessary stability. This is feasible considering the relatively short periods of operation in the BLC regime if, in addition, small control forces are used to reduce pilot fatigue.

for large cargo BLC airplane

Test-bed airplane configuration

Modifications to the C-130 to install boundary layer control are shown in Fig. 1.

A plain hinged flap is substituted for the Fowler flap on the C-130 to simplify the BLC nozzle and duct design. All control surfaces are the same size as the C-130, except the rudder, which has been increased in chord 40%. All surfaces are aerodynamically sealed to prevent leakage, which is highly detrimental to the control effectiveness of BLC surfaces. As previously mentioned, the surface deflections are greater on the test-bed airplane. For example, the flap deflections on the BLC Hercules for take-off and landing are 40 and 60 deg, respectively, for the C-130 they are 18 and 36. The production airplane is designed to use 60 deg for take-off and 90 deg for landing.

The air for boundary layer control is supplied by lightweight turbine engines mounted in pods beneath the wing. For the test-bed airplane, two Allison YT-56-A-6 engines were used. The ducting system in the BLC airplane is shown in Fig. 2, and a typical duct section is illustrated in Fig. 3.

The rudder and elevator have nozzles on both sides, and have their airflow controlled by diverter valves, which direct the flow to the side opposite the deflection. The flow over these surfaces varies from half flow on both sides at neutral deflection, to full flow on the appropriate side at about 30-deg deflection.

A full-power control system, with artificially de-

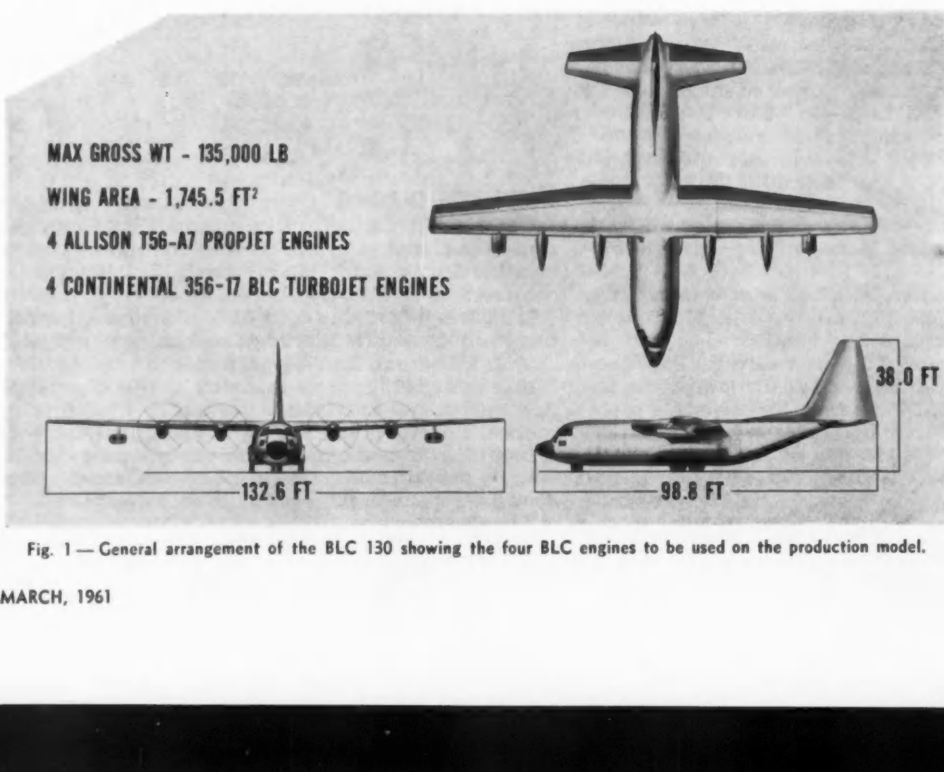


Fig. 1 — General arrangement of the BLC 130 showing the four BLC engines to be used on the production model.

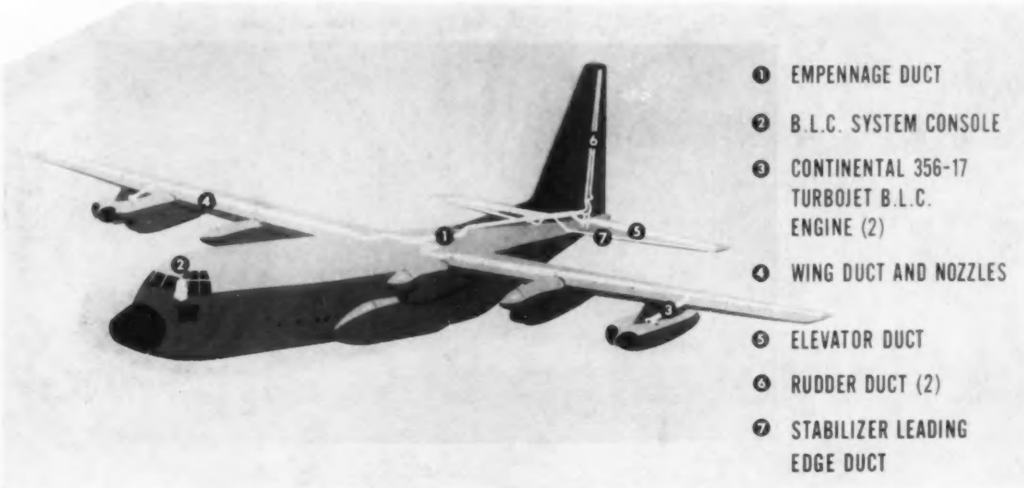


Fig. 2 — Air ducting system for complete boundary layer control. None of the ducts are located in a moving surface — an advantage of the blowing system over the suction system.

STOL demonstrated feasible for large cargo BLC airplane

. . . continued

rived cockpit control forces, is employed on the BLC Hercules, due to the erratic surface hinge-moments caused by the effects of propeller slipstream and boundary layer control flow. The artificial feel system consists of simple preloaded mechanical springs.

Wind-tunnel program

Results of over 800 different wind-tunnel tests showed the longitudinal stability reduction due to power effects was of the same order of magnitude as expected from the initial analysis. They also showed, as expected, that the trim shift due to flaps, power, and BLC help to keep a stable elevator-position versus speed curve . . . . an essential item for successful flying qualities. The directional stability was not reduced by power effects (contrary to C-130 experience), probably because of the large downwash.

The expected tendency toward lateral instability, due to spanwise shifts with sideslip of the lift due to propeller slipstream, was also verified.

The tests also revealed a loss of elevator effectiveness due to horizontal tail stall at the lowest operating speeds of the BLC airplane. To solve this problem two modifications were made: (1) a permanent leading edge upward deflection of 30 deg with blowing at the base; (2) a leading edge with blowing at 2% chord.

Additional tests showed that either of these modifications would increase the maximum lift and the angle for maximum lift above those occurring for speeds below 50 knots. The blowing required was equal to that on the elevator.

Flight simulator program

A flight simulator was built to test the thesis made in the BLC airplane design that the airplane can be satisfactorily flown with highly effective controls, despite neutral or slightly negative longitudinal stability, and definitely negative lateral stability.

The tests covered take-off from zero to 100 knots, including ground effects and lift-off. The control problems resulting from wind gusts, ground effect changes, and critical outboard engine failure, were studied.

Within the limitations imposed by its fixed position, the simulator showed that a large cargo airplane could be flown with high control effectivity, although neutrally stable. The C-130 autopilot was used to fly the simulator with very little greater success than the human pilot. (The slow response is undoubtedly the major contributor to this result).

Flight test program

The flight test program, completed in 23 hr of test time, was aimed at demonstrating the short take-off and landing capabilities of the BLC airplane. It consisted of two parts:

1. Slow-speed flight with BLC and power, including stalls to determine handling characteristics.
2. Take-off and landing performance.

Full power stalls were made on the BLC airplane and were found to be characterized by wingtip stall outboard of the propeller. With the tip stall, a corresponding decrease in aileron effectiveness occurs. Due to propeller slipstream, no significant stalling occurs over the flap.

The decrease in aileron effectiveness limits the minimum speed available. The pilot feels this de-

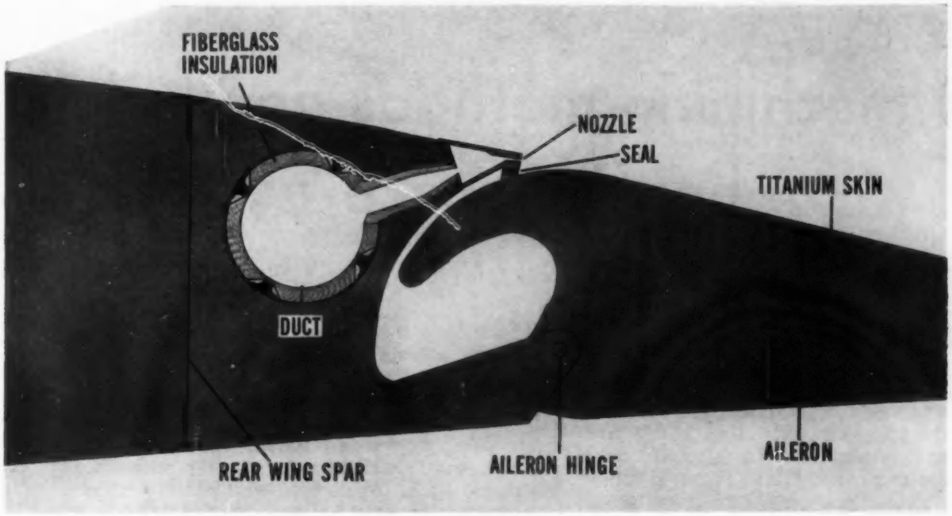


Fig. 3 — Typical cross-section of BLC air duct. The insulation can hold full system pressure in the event of a manifold rupture.

crease in response to aileron control input and breaks off the approach to the stall. During the approach to the stall, there is a slight tendency for the nose to rise and, at the stall, the left wing tends to drop, due to the large effects of engine torque.

The wind-tunnel tests had predicted these stall characteristics, and the estimated stall speeds reflected them.

At flight speeds of 70 knots and above, control and stability are more than adequate. Low-altitude flights with the ramp door open, simulating aerial drop capacity, have been made at 70 knots with a flap deflection of 40 deg. Below this speed there is a gradual deterioration of stability until the airplane stalls. The flight test program had demonstrated that adequate flying qualities existed for flight at low speeds, despite lack of control centering and loss in aileron effectiveness at the stall.

The problem of horizontal tail stall failed to develop during the flight-test program. Neither the uptilted leading edge nor the leading edge blowing slot has been required.

The predicted effect of the failure of an outboard engine to cause critical roll control was confirmed by the flight tests. The loss in lift behind the dead engine creates an asymmetric lift that cannot be controlled by the ailerons. The minimum control speed becomes a three-engine stall speed, which is approximately 10% above the all-engine stall speed. Assuming the three-engine stall speed varies with altitude similar to the all-engine stall speed, the minimum control speed at sea level is 55 knots.

The effect of a BLC engine failure was demonstrated to be very small. Stall occurred at 62 knots under these conditions — again applying an altitude correction reduces this speed to 57 knots.

In determining acceleration characteristics during taxi runs, preliminary to the short-field take-off, difficulty was experienced in keeping the plane on the ground beyond 60 knots with a 60-deg flap. The main gear lifted off and the pilot forced the nose wheel back on the ground. The airplane flew down the runway wheelbarrow fashion. Reducing the flap deflection to 40 deg increased the acceleration and reduced the attitude problem.

Take-off test results showed that, for a gross weight of 100,000 lb, the BLC airplane can get off the ground in 750 ft, and over the 50-ft height in 1390 ft.

Landing-distance tests showed that, for a gross weight of 100,000 lb and 60 deg of flaps, the ground distance is 690 ft. The touchdown speed is 70 knots — slightly higher than estimated. The use of 90-deg flaps will require more power, and can either reduce the air distances or decrease the touchdown speed and ground-roll distances.

Further flight-testing is contemplated to develop the following:

- Increased aileron effectiveness at the stall.
- More accurate low-speed air system.
- Decreased breakout forces and improved control centering.
- Elevator control forces within specification requirements throughout the speed range.
- Landing procedures for minimum over-the-obstacle performance.

The BLC equipment worked exceptionally well during the flight-test program. No difficulties arose with the main ducts. Nozzles were adjusted once, to even out the airflow near the tips. The feel control system worked satisfactorily except for the q-bellows originally used for elevator feel. This was replaced by a simple spring.

The production airplane will require very little change from the test-bed, except for the BLC engines. Four Continental 170 engines will be used, and will increase flow to allow reduced take-off and landing distances to approximately 500 ft on an unprepared field, as required by GOR 130.

To Order Paper No. S259 . . .
from which material for this article was drawn, see p. 6.

New machining methods needed for heavier space-age metals

Based on report by secretary **Ken Sparling**
Lockheed Aircraft Corp.

CORROSION-resistant steels, titanium, nickel base alloys, and high-strength tool steels are replacing the light metals in both aircraft and spacecraft. New and improved metal removal techniques must be found so that weight may be saved in the designs. Electrical discharge, electrolytic, electron beam, and plasma jet are new methods using electrical energy as a direct cutting force. Ultrasonic machining applies cutting forces through a direct electro-mechanical linkage. Chemical milling applies chemical energy directly to the problem of material removal. Thermal machining gives promise of greater metal removal rates and longer tool life using conventional machining equipment.

Electrical machining methods

Electron beam machining is an outgrowth of the electron beam microscope and electron beam welding. A high velocity beam of electrons is focused upon the workpiece and does the cutting. The whole system (including the workpiece) must be operated in a vacuum of about 0.03 micron Hg.

Fig. 1 shows the basic features of electron beam welding and machining. The beam may be focused to a very small size; accurate holes 0.0008 in. in diameter can be produced.

The energy density obtained in average electron beam machining operations will run about 100 times the energy density in a tungsten arc. Energy densities up to 10,000 times the average tungsten arc density have been used in drilling. (One automatic installation has been used to drill 600 jewel bearings per hour.)

The electron beam process provides accuracy, can be tape controlled, and can be used to machine any material.

Electric spark discharge is a second promising electrical machining method. Fig. 2 illustrates the essential elements of the process. A servo system maintains a constant gap of about 0.001 in. between the work (anode) and tool (cathode). The work is submerged in a light oil. A spark is discharged across the gap from a condenser bank as the voltage builds up. With a decrease in voltage the spark is quenched. This process continues at a rate between ten thousand and one million cycles per second. Actual metal removal is believed to be by melting under each spark discharge.

Electric spark discharge machining has some limitations — the workpiece must be electrically conductive, local heat effects may cause cracking, residual stresses may be high, fatigue life may be adversely affected and decarburization may result. On the other hand surface smoothness may be held to 10 microin, and tolerances of 0.0001 in. are possible. Hardness or other mechanical properties have little effect on cutting speed. Intricate shapes may be cut and controlled depth die cavities formed. Since no pressure is applied to the workpiece, the process can be used for honeycomb contouring.

Another electrical machining process is electrolytic grinding (Fig. 3). This process is similar to the electro-discharge method in that the workpiece is the anode and the tool the cathode, and both are submerged in a liquid. In this case material removal is by electrolytic action or deplating. The fluid is an electrolyte such as potassium nitrate and the grinding wheel must be electrically conductive. The abrasive must be nonconductive such as diamond or aluminum oxide. The abrasive prevents a direct electrical short and wipes away from the ion film formed. The workpiece must be electrically conductive. Workpiece mechanical properties do not affect metal removal rates. No pressure is applied to the workpiece and no heat is generated. Surface finishes down to 2 microin. are claimed with conventional grinding tolerances. Metal removal rates are faster than with electro-discharge methods but irregular die cavity sinking is not possible.

One new variation of the electrolytic grinding process is the electrolytic jet. Fig. 4 illustrates the features. Here, an electrolyte is forced through a hollow tool cathode and impinges on the work. A heavy current passed through the electrolyte causes metal removal. Hole drilling and cavity sinking is possible with this electrolytic method.

Ultra high speed machining

Ultra high speed machining at speeds up to 240,000 sfpm is still in the research stage. Currently, the highest production cutting speeds are around 15,000 sfpm in the light metals.

A typical test apparatus consists of a smooth bore 20 mm cannon with a single load breech and muzzle extension to hold the cutting tool. By varying the type and weight of the powder charge in the hand loaded cartridges and the weight of the projectile, cutting speed can be varied. Speeds from 15,000–240,000 sfpm are possible. Satisfactory cuts are reported on all high strength materials tested. Surface finishes for all materials ranged from 3–99 microin. with no change due to speed. Shear force appears to decrease with an increase in speed. Cutting temperature did not rise. Comparison of tool wear with that of conventional planer cuts on

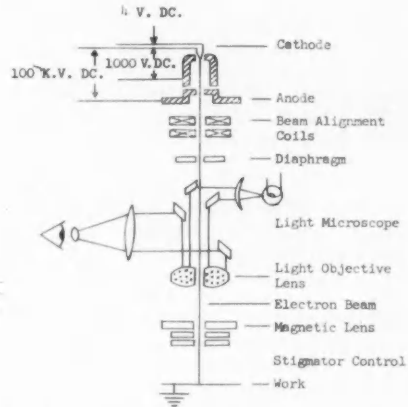


Fig. 1 — A high velocity beam of electrons is focused upon the workpiece and does the cutting in the electron beam machining process.

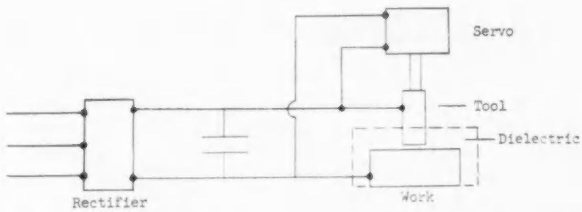


Fig. 2 — A spark discharged across a gap at a rate between 10,000–1,000,000 cps removes metal in the electro-discharge machining process.

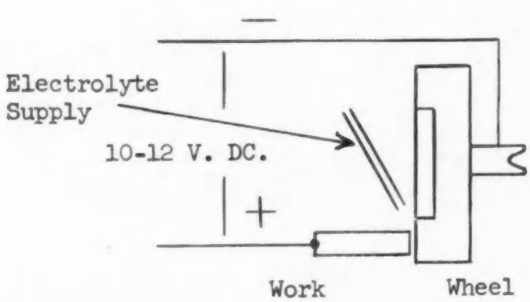


Fig. 3 — Material removal is by electrolytic action or "deplating" in the electrolytic grinding process.

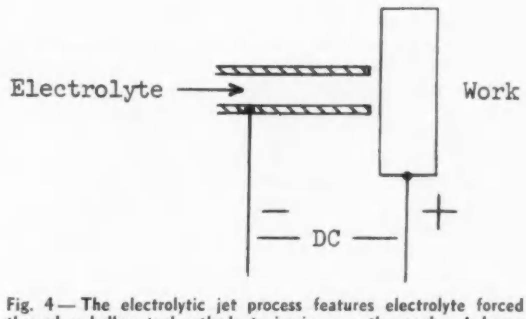


Fig. 4 — The electrolytic jet process features electrolyte forced through a hollow tool cathode to impinge on the work. A heavy current passed through the electrolyte causes metal removal.

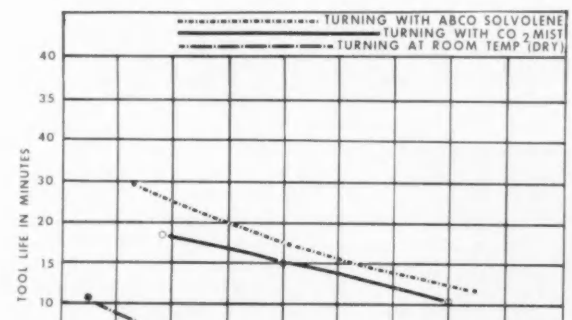


Fig. 5 — Increases of up to 300% in tool life or cutting speed were experienced using sub-zero coolants on treated cobalt base L-605 of average Rockwell hardness C-20 to C-26.

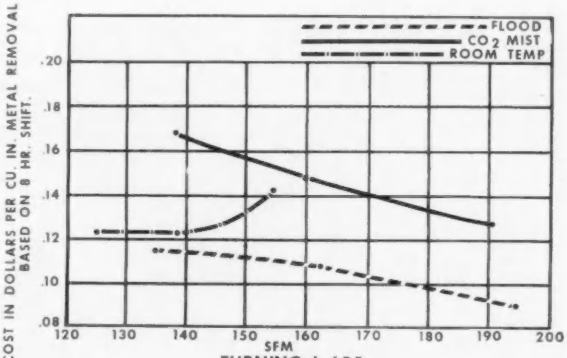


Fig. 6 — Increases in tool life don't always indicate a reduction in cost due to the constant cost of chilling the coolant.

one material showed equal or less wear even though the speed ratio was 5000 to 1.

Chemical milling

The chemical milling process removes metal by immersing parts in a chemical reagent. Area covered by a chemically resistant coating or mask are not attacked. Tapers can be achieved by immersion rate or progressively stripping the mask in bands to produce step tapers. All types of flat or formed, wrought, forged, or cast shapes are well suited to chemical milling. Some of the advantages of the process are stress free metal removal, one piece designs, weight reduction, and production of large, very thin (0.012 in.) skin areas with integral stiffners.

Tests show that the refractory metals (molybdenum, beryllium, tantalum, and tungsten) can be uniformly etched with good surface finish. The very toxic beryllium can be fabricated with the least hazard to employees by chemical milling.

Thermal machining

Thermal machining is machining at temperatures both above and below normal room temperature operation. Sub-zero machining tests have been performed on cobalt base L-605, nickel base R-235, austenitic stainless A-286, SAE H-11 tool steel and 0.5% Mo titanium. Turning, milling, drilling, tapping, grinding, and sawing operations were performed. Coolants were CO_2 mist and ABCO 156A Solvoline as a flood with both operating at −110 F.

Tensile tests showed no change in strength or microstructure after being chilled. Increases up to 300% in tool life or cutting speed were experienced in single point turning. However, increases in tool life do not always indicate a reduction in cost due to the constant cost of chilling the coolant. The effect of sub-zero coolants on tool life is shown in Fig. 5 and on cost in Fig. 6.

When turning SAE H-11 tool steel (Vasco Jet 1000) with sub-zero coolants tool life increased over 200% but cost remained lower when machining at room temperature. In general, cutting speeds or tool life can be increased from 50–300% above room temperature values by using sub-zero coolants. The cost per cubic inch of metal removal usually decreases with an increase in metal removal rates.

Carbide milling is not usually improved by sub-zero coolants. One high speed end mill application showed an increase in cutting speed and a decrease in cost when using the sub-zero technique.

Sub-zero coolants can not be universally used as a cure-all. Although higher cutting speeds can generally be achieved, part design or machine limitations may restrict their use. Small diameter turning, short length cuts, and the inability of a machine to follow a template when profile milling often place production restrictions on speed.

Tests also show that the efficiency of metal removal is increased when turning at elevated workpiece temperature. Tool forces and the work done in cutting are reduced. Tool temperatures do not increase in proportion to the workpiece temperature increase. Induction heating to 1000 F has improved tool life twenty times on a face milling setup cutting 17–4 Mo steel. The same temperature improved tool life 100 times when cutting Thermold J material. Fig. 7 shows the effect of workpiece temperature on tool life. The limiting temperature occurs at about 1200 F when welding between chip and tool begins.

To date no improvement in cutter life has been observed through hot drilling. Tempering of the workpiece occurs when the tempering temperature is exceeded. Depth of softening depends on localization of heating. Methods of concentrating the application of heat to the zone of plastic deformation in receiving current research emphasis. Surface finishes are as good as those obtained at room temperature. Workpiece distortion due to heating, however, presents a problem in attempting to hold finish tolerance.

SERVING on the panel which developed the information in this article, in addition to the panel secretary, were: chairman **E. A. Green,** Lockheed Aircraft Corp.; co-chairman **R. L. Schleicher,** North American Aviation, Inc.; **L. B. Sterns,** U. S. Chemical Milling Corp.; **R. R. Cole,** University of California; **W. L. Carr,** Convair; and **R. I. Vaughn,** Lockheed Aircraft Corp.

(This article is based on a report of one of 14 aerospace manufacturing forum panels. All 14 are available as a package as SP-333. See order bank on p. 6.)

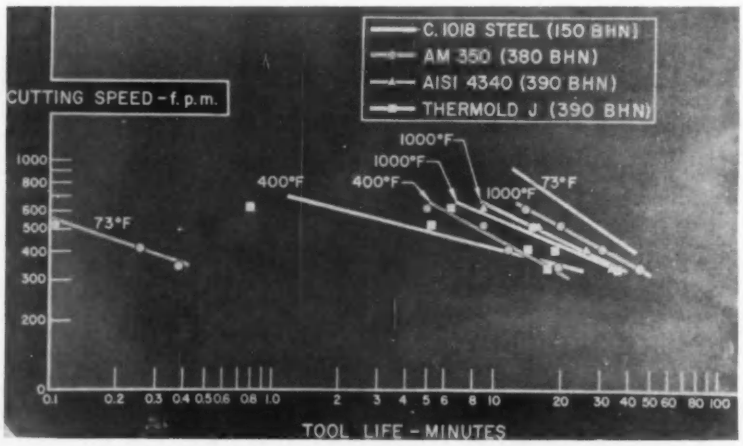


Fig. 7 — Tool life tends to increase with increase in workpiece temperature.

Surface ignition . . .

increases with rise in compression ratio and automatic cycling test can show it as well as road observations.

Based on paper by

E. F. Koenig, J. R. McLean, and E. J. Buchanan, Jr.

Texaco Research Center

SURFACE ignition increases logarithmically with the rise in compression ratio. When this phenomenon is studied by cycling cars on a chassis dynamometer, the results agree well with those observed when cars are driven by consumers.

The automatic cycling device employed in this test simulated level road operation and was designed to approximate a previous road test by running at various speeds interspersed with idle periods. The procedure called for 10 stops per hour and an average speed of about 28 mph. No surface ignition count was made for the first 1000 miles, inasmuch as previous work had shown that it takes that number of miles to reach an equilibrium deposit level. The count was obtained on clean engines after 1000 miles and every 6 hr thereafter until five such ratings had been obtained.

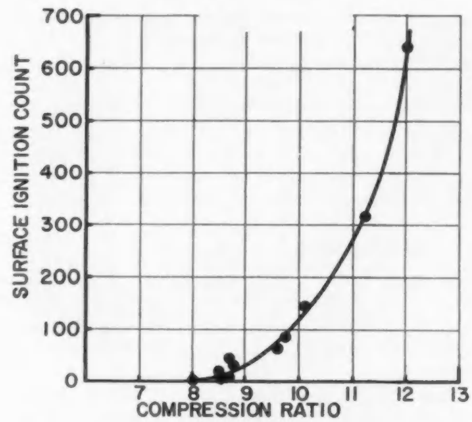


Fig. 1 — Test data from a group of 1960 cars show the rapid increase in surface ignition that accompanies a rise in compression ratio.

Surface ignition count

Surface ignition count versus compression ratio for nine standard production 1960 cars and two equipped with high compression engines is shown in Fig. 1. Here is illustrated the rapid rate at which surface ignition increases with compression ratio rise. If these same data are plotted semilogarithmically (Fig. 2), they show that for a given fuel and set of operating conditions:

1. Below 8.5/1 compression ratio, surface ignition was essentially nonexistent.
2. At 8.5/1 compression ratio, incipient surface ignition was encountered.
3. Between 8.75/1 and 12/1, surface ignition increases logarithmically with compression ratio.

A similar semilogarithmic plot of data obtained from six 1959 cars, one 1958 model, and another car equipped with a special high compression ratio engine showed the same general relation between surface ignition and compression ratio evident in the 1960 cars.

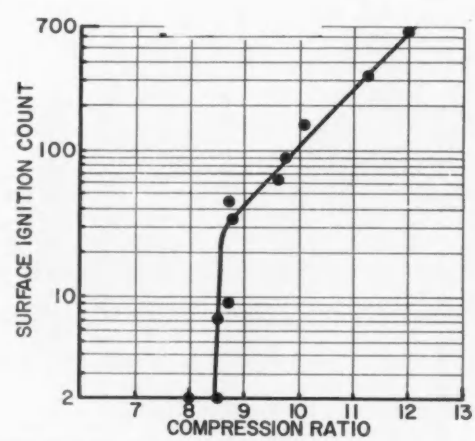


Fig. 2 — Same data as for Fig. 1, plotted semilogarithmically, show that, for a given fuel and set of operating conditions, surface ignition increases rapidly as compression ratio rises above 8.75/1.

Laboratory-road correlation

Establishing the degree of correlation between laboratory test and consumer service is of para-

mount importance, therefore comparison was made with data obtained in the 1959 CRC Octane Requirement Survey. One of the observations made in that survey was the occurrence of rumble on tank fuel. These data have been analyzed by expressing the number of cars rumbling as a percentage of the total number of cars tested for each make and model on which more than 20 observations were made. The plot of these percentages against compression ratio is shown in Fig. 3.

The correlation is not perfect because the cars had been subjected to all types of operation prior to rumble rating, were run on a wide variety of fuels and lubricants, and were rated by various observers at different locations and ambient conditions. Nevertheless, the data fell generally into a fairly narrow band. The one exception would have fallen into the band, had the compression ratio been 10.5/1 instead of 10/1. The 1958 model of this car was advertised as having a 10.5/1 compression ratio. In this rather limited range of compression ratios, the incipient rumble occurs between 8.5 and 9.0 compression ratio and above 9.0 rumble increases rapidly.

The similarity between these data and surface ignition data obtained on the chassis dynamometer in the laboratory (Fig. 1) would seem to show that the laboratory test gives a reasonably good indication of surface ignition in customer service.

Knock observations

Significant full-throttle spark knock was observed with the test fuel with engines having a compression ratio greater than 10.5/1; only a small amount of knock occurred on two of the lower compression ratio cars.

Hot starting knock occurred on most of the cars tested with compression rates above 9.51. Generally, the intensity and frequency of occurrence increased with compression ratio.

No idle run-on occurred, except for a single instance with one of the 12/1 compression ratio engines.

To Order Paper No. 260C . . .
from which material for this article was drawn, see p. 6.

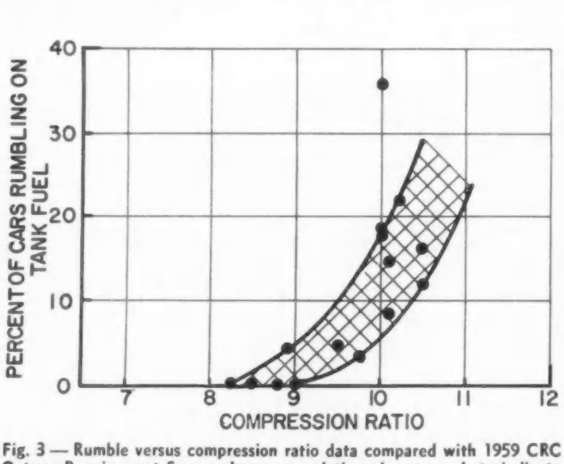


Fig. 3 — Rumble versus compression ratio data compared with 1959 CRC Octane Requirement Survey show a correlation close enough to indicate value of laboratory test as a means to determine surface ignition of cars in customer service.

Coatings Protect Materials from Flight Heat

Based on report by

A. G. Lucas

Boeing Airplane Co.

TWO TYPES OF COATING are being used to protect materials from aerodynamic heating:

1. **Static coatings for refractory metals and graphite.**
2. **Ablative or expendable coatings.**

Fig. 1 shows how the strength-to-weight ratio of some of the newer constructional materials falls off with increase in temperature. Molybdenum, columbium, and graphite must be coated to be useful at the higher flight speeds. These materials show rapid oxidation rates in the temperature range where they are useful (Fig. 2).

Molybdenum is best protected by molybdenum disilicide which provides excellent oxidation resistance. Fig. 3 shows a typical wing leading edge section that has been coated with molybdenum disilicide. The coating is applied by vapor decomposition of silicon tetrahalide in a carrier gas such as hydrogen. This reaction is conducted at approximately 1900 F. The major problems with the process have been:

1. Part support to obtain a uniform coating without any breaks.
2. Temperature measurements in a corrosive atmosphere.
3. Determination of the optimum operating temperature.
4. Materials that can contain the corrosive gases.

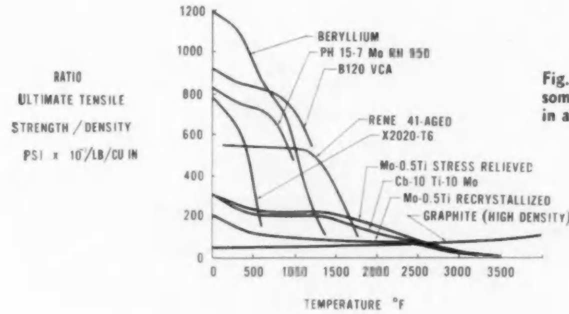


Fig. 1 — Ultimate strength-density data for some of the newer structural materials used in aircraft.

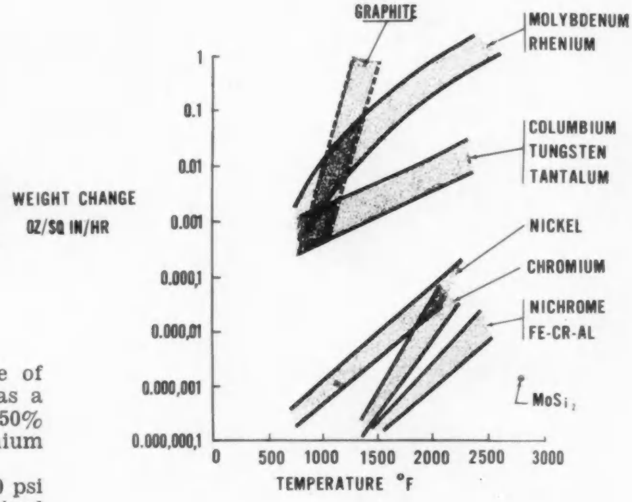


Fig. 2 — Air oxidation rates of various metals and alloys. Molybdenum, columbium, and graphite must be coated to protect against their normally rapid oxidation rates.

For the protection of graphite, a composite of graphite and ceramics with furfuryl alcohol as a binder is used. A typical composition is: 50% graphite, 24% moylbdenum disilicide, 25% titanium boride, 1% binder.

The composite is pressed at 5000 psi to 15,000 psi prior to air cure, air cured at 300 F, and graphitized at 3500+ F. Under operation, the graphite burns away and the exposed ceramics fuse into a protective layer. This system is limited to 3000 F and further research is in progress to develop systems that will withstand higher temperatures. These include more refractory composites and flame sprayed alumina with a sealing spray of silica.

Ablative coatings are used to protect substructure and instrument packages from the high temperatures caused by aerodynamic heating. The coatings sublime and therefore keep the temperature below their sublimination temperature in the same way as water in a kettle will not allow the temperature to rise above 212 F. A wide range of organic polymers or plastics are used to protect from temperatures as low as 400 F and as high as 16,000 F.

The selection of a given material depends upon the environment of the intended use. Common materials used for ablative coatings are phenolic-asbestos, epoxy-fiberglass, and molded Teflon.

The manufacturing problems in making ablative hardware are cause by the nature of the material itself and the fact that not only is the shape changed but a new molecular structure is chemically formed. For this reason, close process control is necessary and a high degree of operator skill is required to make in-process adjustments to compensate for variations in raw materials.

(This article is based on a report of one of 14 aerospace manufacturing forum panels. All 14 are available as a package as SP-333. See order blank on p. 6.

Fig. 3 — Typical wing leading edge section is coated with molybdenum disilicide to provide oxidation resistance.

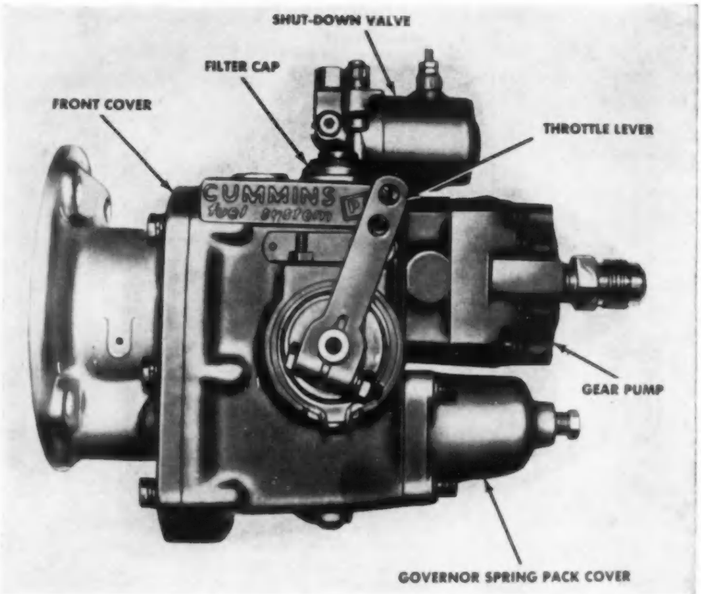


Fig. 1 — Final design of PT fuel pump. Governor and pressure-control parts are in the lower half of the pump with governor weights rotating at 1.88 X engine speed. The pump flange is mounted without external couplings and brackets. The pump weighs 12.2 lb; is 9 in. long.

Governing action and fuel metering pressure provided by same parts in

NEW pressure-time fuel pump

Based on paper by

N. M. Reiners, R. C. Schmidt, and J. P. Perr

Cummins Engine Co., Inc.

IN the new Cummins PT pressure-time fuel pump (Fig. 1) the same parts that perform the normal governing action are also used to provide the desired fuel pressure for metering throughout the entire operating range. Normal minimum and maximum speed governing has been maintained, and fuel metering to the injector is insensitive to internal leakage and variation in gear-pump delivery.

By proper selection of a combination of governor weights and springs, the pressure delivery characteristic can be tailored to a variety of engine requirements.

The only parts of the PT pump, as used on present production engines, which differ are: torque control spring, pressure control button, and governor spring. This single pump design is designed to cover a horsepower range from 70 to 700.

The diagram shown in Fig. 2 is the basic PT fuel-flow system. Fig. 3 shows a cross-section of the main components. There is a central main housing containing the governor in the lower half. All of the subassemblies are bolted to the main housing. The front cover contains the drive parts for both the gear pump and the governor. The gear pump, the shutdown valve, the tachometer drive, and the filter are attached as subassemblies to the main housing. The throttle shaft is assembled in a bore at right angles to the driveshaft in the main housing. There are no check valves in either the fuel

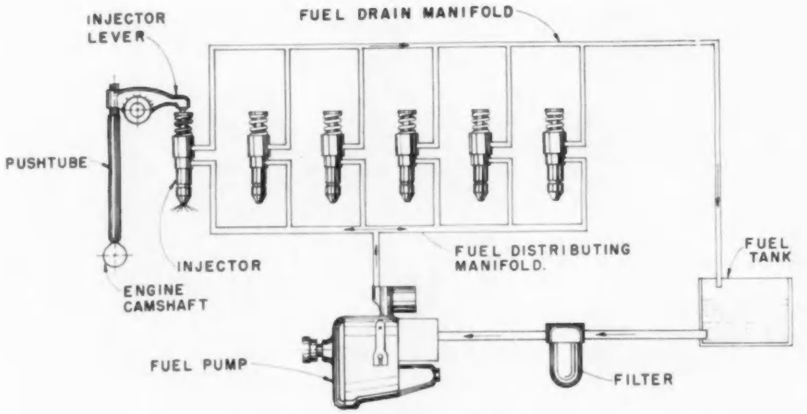


Fig. 2 — Basic fuel-flow system for new Cummins PT fuel pump. The fuel is drawn by the gear pump from the fuel tank through a filter and delivered to the individual injectors through a common conduit. Fuel circulated through the injectors primes the system and scavenges air; then is returned to the fuel tank through the fuel drain manifold. The distribution and metering functions are separate from the injection function.

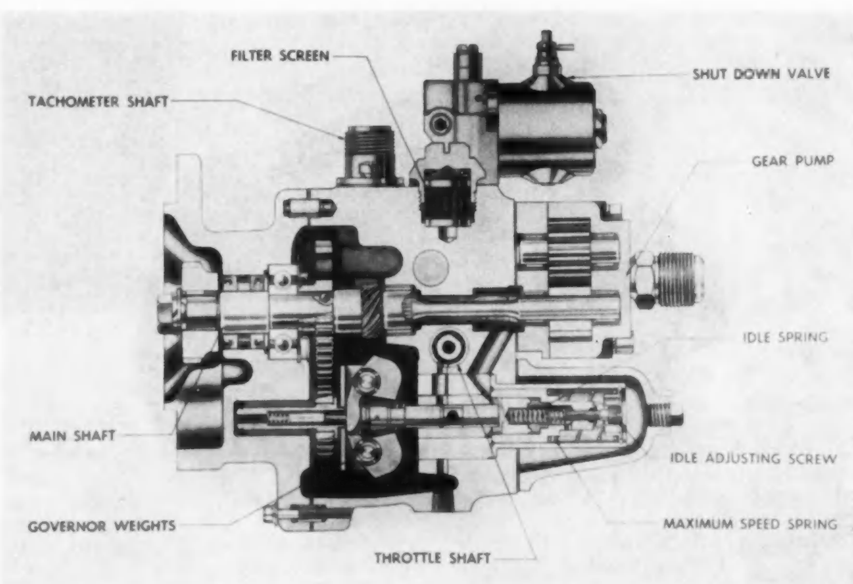


Fig. 3 — Cross-section of main components in PT fuel pump.

pump or in the entire fuel system.

The governor is a set of flyweights driven in direct proportion to:

- Engine speed.
- A plunger which rotates with the governor weights and reciprocates axially in a fixed sleeve.
- A governor spring pack acting in opposition to the governor weights at the opposite end of the governor plunger.

Basic functions of the fuel pump are to:

- Provide fuel pressure to injector as needed to produce the desired full-load torque curve.
- Provide means for part-throttle operation.
- Limit the maximum speed of the engine with stability and consistent regulation.
- Control idle speed with closed throttle and varying load.

The supply pump for the PT fuel system is designed to deliver two or three times more fuel than is required to operate the engine at maximum power.

At low engine speeds, some engines may require an increase in fuel pressure over that normally supplied by the basic governor characteristics. For this case, a spring can be added to increase the fuel pressure at low engine speeds. This low-speed torque control is mounted on the governor driveshaft. The spring preloads the governor weight, increases the net force on the plunger, and increases the fuel pressure. Above a preselected speed, the spring is fully extended and will have no effect.

To Order Paper No. 258B . . .
from which material for this article was drawn, see p. 6.

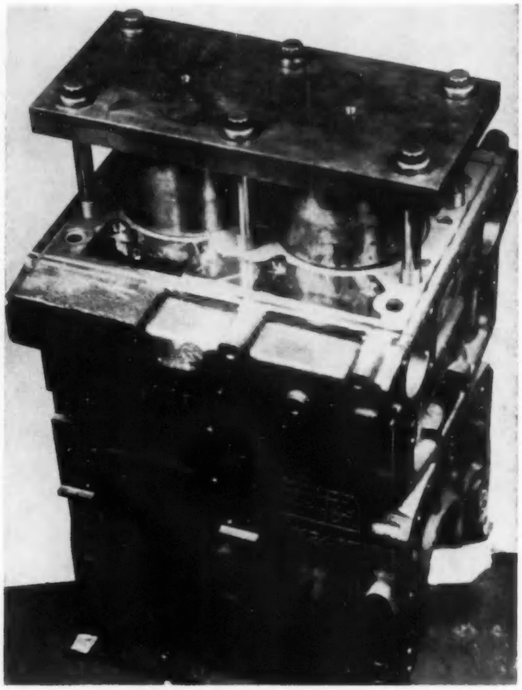


Fig. 1 — Test setup for simulating head installation forces on the cylinder block. Production bolts, used at standard installation bolt torques, hold the steel plate against the spacers.

Photostress

—New technique in stress analysis

Based on paper by

R. M. Law

Detroit Diesel Engine Division, GMC

A NEW technique in experimental stress analysis has been developed, which enables the determination of the stress pattern of the entire surface of a test specimen. Photostress, as this method is called, involves bonding to the part to be analyzed, a special transparent plastic which becomes birefringent when subjected to the transmitted strain of the test object. By utilizing a white polarized light or room lighting, a complete color picture of the strain distribution over the entire surface is obtained, with highlights on the areas of stress concentration. Since the change in color is directly proportional to the intensity of the strain, the location, sign, and magnitude of each strain can be determined instantaneously and with great accuracy. The determination of the magnitude of strain will be illustrated here.

The photostress technique enables strain to be measured in static or dynamic condition, dynamic stress measurement being limited only by the speed of the recording device, either high-speed movies or photoelectric instruments.

Eliminates drawbacks of other methods

A number of other tools of experimental stress analysis have been in use to measure stress in parts having complex shapes, loads, or both. All of them use the principle that stress is proportional to strain and, like the photostress technique, measure strain to get stress values. These other techniques of stress analysis are:

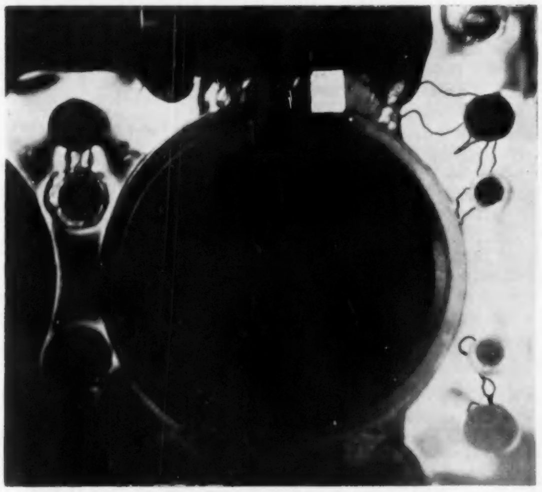
1. Brittle lacquer, commonly known as stresscoat.
2. Electric strain gages.
3. Photoelasticity.

The use of a stresscoat pattern is limited to the threshold or initial cracks. Every point in a photostress pattern is capable of analysis.

A strain gage measures the strain along the longi-

Fig. 2 — High stress gradient between water hole (center) and bolt hole (left), due to bolt installation, is reflected by the concentration of color fringes between these holes. A well-defined crack was observed in the block at this point, after removal of the photostress sheet.

Fig. 3 — Residual strains of the cylinder-block top deck were found to be greatest in the area of highest stress gradient.



tudinal axis of the gage with no indication of the direction of principal strain. For complex surfaces numerous strain gages or stresscoat applications would be necessary to determine the strain values and direction of principal stress.

Conventional photoelastic techniques involve making a transparent plastic model of the part to be analyzed, and determining the strains in the model under a simulated load. The photostress technique employs the actual part as the test object.

Photostress aids cylinder block design

The photostress method was used to determine the areas of weakness in a newly designed cylinder block which had experienced cracks between the cylinder-bolt hole and the water hole in the section of the top deck between adjacent cylinders. The cracks were due to installation of the cylinder head, and not engine operating conditions.

Head installation forces were simulated by bolting a steel plate to the cylinder block, with spacers between the cylinder liners and the plate, as shown in Fig. 1. Production bolts were used at standard installation bolt torques.

The resulting strain or stress patterns observed in the section between adjacent cylinders is shown in Fig. 2. The changing shades of gray in the black and white photograph correspond to changes of color in the plastic. The darkest area represents the transition from red-to-blue or green, and is called the tint-of-passage, or color fringe. These color fringes have been identified by black lines drawn on the photograph. A strain value can be assigned to the color fringe and is the strain necessary to change the color of the plastic from blue or black (zero strain) to the first color fringe. To assign an absolute strain at any point, this strain value is multiplied by the number of color fringes from the zero stress to that point. A concentration of color fringes is an indication of a high stress gradient.

The small black area between the head bolt and the spacer (Fig. 2) represents an area of zero shear stress. Counting from this point to the peak of the stress gradient between the water hole and the bolt hole, five fringes are observed. With the particular plastic used in this test, the five fringes were equivalent to approximately 5000 microin. per in. of strain — which was equivalent to 55,000 psi of stress (assuming $E = 15 \times 10^6$ and Poisson's ratio $= 0.3$ for cast iron).

The permanent deformation of the cylinder block due to the described load were found to be greatest in the areas of highest stress. The residual strains are shown in Fig. 3. A well-defined crack between the water hole and the bolt hole in the top deck was found when the photostress sheet was removed.

Redesign of the cylinder block, taking into account the findings of this test, has eliminated failures due to cracks.

To Order Paper No. 255B . . .
from which material for this article was drawn, see p. 6.

Briefs of SAE PAPERS

Continued from page 6

cant degree, thus calling for improvement of engine and fuel design.

Test Method for Rating Throttle Icing Tendencies of Gasolines, J. H. FREEMAN, JR. Paper No. 264B. Problem of carburetor icing consisting of cold stalling during warmup period, and throttle restriction due to ice formation at highway cruise conditions; engine test method whereby test or reference fuel samples are continuously metered upstream from throttle plate; conclusions regarding resistance of fuel compositions and gasoline additives to both forms of icing are based upon equivalent concentrations of reference alcohol mixture in gasoline of known throttle-icing characteristics.

Volatile Fuels, Road Effects, and Film Studies, W. A. GARTLAND. Paper No. 264C. Study, carried out by Ford Motor Co. to reproduce road operation hot fuel handling performance on chassis dynamometer, consisted of following phases: to establish good road test results which are repeatable and complete, using this data to duplicate results on chassis dynamometers, to film fuel action in carburetor float bowl under actual operating conditions on dynamometer; films taken demonstrate that visual investigations of fuel are practical.

New Technique for Determining Knocking Resistances of Fuels, R. A. Hoffman. Paper No. 285C. Describes instrumentation and techniques developed to use it for determining the knocking resistance of fuels. The knock-detection system used with this knock-count technique is responsive only to high frequencies of the gas vibrations asociated with knock. The system eliminates "knockless" knock ratings and makes it possible to rate a fuel at a knock intensity equal to that of its matching primary reference fuel.

GROUND VEHICLES

Chassis and Total Car Reliability, J. R. GRETZINGER. Paper No. S260. Background of reliability concept and program at Buick which covers following functions: to assist in establishment of reliability goals, to review design, processing and quality control, to make predictions on reliability, and to take corrective action; differences between reliability and quality control; failures in reliability, caused by design, quality, or service problem; structure of organization of Reliability and Quality Control Div. and phases of program.

Initiating Body Reliability Program, W. E. SEHN. Paper No. S261. Concept of reliability as applied at Fisher Body Div. of General Motors; areas in which there is need for reliability function: control and use of existing reliability facilities and functions; prevention of recurrence of error of design, manufacturing, and assembly; resolution of frequent customer complaints; creation of new products, materials, or processes; new reliability measures, collection and evaluation of data; organizational structure required to control reliability program.

Body Component Reliability, A. J. HOFWEBER. Paper No. S262. Approach applied by Ternstedt's Div. of General oMtors to obtain component reliability in initial tooling and production phases; Reliability Section and its functions which include working with production engineering on tool design, equipment capabilities, and design recommendations, with manufacturing staff on processes and production capability studies, and with quality control group on statistical quality control data, in-plant test data and failure reports; new developments and their relation to reliability; examples.

Scientific Highway Design for Safer Motoring, K. A. STONEX. Paper No. S264. Accident statistics during 1953–1958 revealed total of 236 accidents, of which 72% were off-the-road; examination of roadside hazards such as trees, ditches, guard rails, etc and relation of slope of bank and stability of car; development of design standards identified as General Motors Proving Ground 1960 Road Section Design Standards; elements of concept; cost of accidents list of average daily traffic volumes for highways in Detroit area.

Engineering for Safety With Psychological Yardstick, G. J. HUEBNER, Jr. Paper No. S265. Problems of evaluating automotive developments in terms of their design suitability and adaptability to human use; ability of man to compare two different quantities was used at Chrysler Research to develop technique for measurement of riding quality of cars; examples given from projects in which analysis of subjective appraisals was used include studies of tire thump and roughness, body shake, engine and exhaust noise, seating comfort, etc.

Progress in Safe Vehicle Design, R. H. FREDERICKS. Paper No. S266. Accident reducing factors, dealing with vehicle design for improved automotive safety, and study of driver's motivation and response patterns; principal causes of occupant injury; features developed for reducing risk of injury include energy-absorbing recessed hub steering wheel, padded instrument panel and sun visors, rearview mirror using adhesive backing to minimize risk of flying glass, lap-type seat belt, energy-absorbing arm rest, and safety door latch.

Corvair's Challenge to Body Builder, B. COTTER. Paper No. S267. At Fisher Body Div. of General Motors challenge consisted of designing parts, methods of assembly, and providing facilities to build frame-integral body for car with aircooled rear-mounted engine; structural composition of Corvair body designed to assure continuity of load distribution, and to react as unit to absorb all loads applied; use of master gage and leveling fixture for underbody to coordinate fabricating plant tooling, assembly plant building fixtures, etc.; laboratory and proving ground testing.

Diesel Engine for Medium-Duty Trucks, W. E. PETERSEN. Paper No. S269. International Harvester model D-301 diesel engine is heavy duty, high speed, light weight engine for pickup and delivery, 16,000 lb to 18,000 lb GVW truck; it develops 112.5 gross horsepower at 3000 rpm and weighs 122 lb.; D-301 is one of family of four diesels adapted from gasoline engines; design changes made to produce engine are enumerated and explained.

Controlling Valve Oil Consumption, R. W. HEID, Jr. Paper No. 249C. Valve stem and guide must receive sufficient lubrication to prevent scuffing and excessive wear; problems created when excessivve amounts of oil pass down valve stem into combustion chamber or exhaust port; ways, means, and results of preventing oil from reaching these via valve stem route; experimental designs of positive type valve stem seals; combination valve stem seal and valve guide, designed by Perfect Circle Corp.; examples showing effects of using positive valve seals.

Two-Speed Tandem Drive Axles, R. K. NELSON, L. J. VALENTINE. Paper No. 250A. Two-speed tandem development in motor-truck axle design at Eaton Mfg. Co. began in 1956 in effort to reduce weight, descrease length of forward-drive axle, simplify power divider, and to use as many existing parts of common drive axles as possible; paper covers reasons for 2-speed tandem, its development and operation, applications for 2-speed tandem, and future developments in other types of multispeed tandem-drive axles.

Winterization of Military Vehicles, R. SHAW. Paper No. 251B. Equipment and techniques employed in starting and operating vehicles in arctic and subarctic regions; problems imposed on vehicle operation and theory

and techniques employed by Ordnance; winterization equipment and techniques developed for heating engines and related components to condition for starting are standby heat and quick heat technique; hardware used; combination electric and hot-air heating kit; most effective aids in starting and idling of air-cooled compression-ignition engines listed.

Basic Considerations for Selection of Over-the-Road Vehicles, J. B. BOYNTON. Paper No. 252B. Line-haul vehicle must be built to following specifications: lower first cost to satisfy top management; lower operating costs to satisfy operating department; better salvage or resale value to satisfy accounting department; and more comfort and convenience to satisfy driver; consideration of highway safety factor inherent in design.

Selecting Right Vehicle for Job — Door-to-Door Delivery Vehicles, H. G. STETGERWALT. Paper No. 252A. Approach taken by National Dairy Products Corp. in selecting new delivery vehicle; steps in study to establish vehicle requirements, to review performance of existing equipment, standardized fleet, and to investigate available equipment; determination of chassis and body specifications; performance requirements; evaluation of quotations in light of past experience with same or similar line, and in terms of established maintenance and operating preferences.

Selecting Vehicle for Job — Passenger Car Fleet, H. O. MATHEWS. Paper No. 252C. Selection of passenger cars used by salesmen, buyers, engineers, foremen, supervisors, etc., involves following considerations: original cost, extra equipment, area of operation, prestige factor, life expectancy, resale value, maintenance, company advertising, and management policies; discussion of each factor.

Selection of Vehicles for Public Utility Service, C. C. HUDSON. Paper No. 252D. Factors to consider in selection of trucks carrying materials and tools used in construction and maintenance of water, gas, telephone, and electric-power systems; recommendations made with regard to better bottom protection of parts, components, and accessories; engines and cooling systems should be designed for near-continuous stationary operation; fleet needs for standardization, to keep parts stocks, service tools, and training; list of users criticisms and suggestions.

Stress Analysis of Aluminum V-8 Diesel Cylinder Block, H. W. VAN CAMP. Paper No. 255A. Role of experimental stress analysis in development program for cast aluminum block, developed for Ordnance Corps. by Caterpillar Tractor Co.; testing of block and basis for interpretation of analysis; criteria for evaluating aluminum castings for fatigue; results discussed are limited to four areas of block, one of which correlated stress measurements and their interpretation with fatigue fractures occurring in initial prototype engine tests.

Dodge Truck Heavy Duty V-8 Engines, H. L. WELCH, R. S. RAREY. Paper No. S257. Purpose of gasoline engines was to provide power for improved line of trucks ranging from 22,000 to 65,000 lb. GCW; background that influenced basic design; family comprises 361 cu in. size available at three different power levels for use in 600, 700 and 800 model trucks; 413 cu in. size is available in two power rangings for 900 and 1000 models; specifications for each engine; constructional details; lubrication system is conventional and oil spray is used to lubricate pistons and pins; results obtained.

What Car Expects of Battery, R. C. HAEFNER. Paper No. 269A. Battery behavior in car may be regarded as discharge and charge functions, considered separately with regard to battery testing; it is shown that most batteries in voltage regulated systems spend their service life at states of charge below fully charged state; battery is expected to endure at various levels of balance; wide applicability of condition suggests advisability of durability test proposed, in place of present practices; present standard test procedures should be re-examined.

Choice of Battery Systems, C. G. GRIMES, W. S. HERBERT. Paper No. 269D. Evaluation of status of lead battery, as compared to other competitive systems; factors in considering choice of battery system to best fulfill requirements of application; comparison of battery systems (100 amp-hr batteries — 12 v); development of practical fuel cell and its major components; it is believed that lead-acid battery will maintain its position in storage battery field as preferred auxiliary power source.

Improved SAE Battery Cycling Life Test Equipment, R. D. BREWER. Paper No. 269G. Development of improved Type A additional SAE cycling life test stands, used at Ford Motor Co. in testing of batteries; details of three test stands and major components specified to handle total required capacity of 120 batteries; each stand is complete unit comprising 10 controllers, tank, power supply, and other essentials for operation; controller schematic diagram; operating experience shows improvement in accuracy of control and uniformity of test conditions.

Relationship of Physico-Chemical Properties of Active Materials to Capacity for Lead-Acid Batteries, R. J. BRUMBAUGH. Paper No. 269H. Study made at Electric Storage Battery Co. to determine effect of physical state of active materials of lead-acid batteries on ampere-hour capacities, and how raw-materials and plate processing altered physical state of active materials; effect of particle size of oxide raw material and rates, specific gravity, and temperature of formation; tables.

Vibration-Proof Lead-Acid Batteries, R. L. BENNETT. Paper No. 269J. New battery construction developed by Electric Autolite Co. eliminates severe vibrations leading to battery failures; use of resin to cement container, plates, and separators in lower part of each cell; integral bond is formed between plates, separators, and container that eliminated possibility of elements vibrating at frequencies different than that of container; materials used include thermosetting resins of epoxy, furfural, or phenolic type; results of laboratory and field tests.

Application of Radiography and Microscopy in Battery Grid Studies, J. F. SCHAEFER. Paper No. 269K. Disintegration of positive grids due to anodic corrosion conditions is major cause of failure of lead-acid storage batteries; program, undertaken by Globe-Union Inc., combining radiographic and microscopic techniques with conventional laboratory methods to obtain data on various phases of grid corrosion; typical corrosion characteristics are shown; changes made in grid design to improve service life.

ALSO AVAILABLE

1960 SAE AEROSPACE MANUFACTURING FORUM . . . SP-333 consists of reports on 14 panels, as follows:

Operations Research Applied to Manufacturing Problems by D. E. Debeau, secretary. A review of some established and some new areas of operations research effort with emphasis on the role of manufacturing personnel in providing information and data and on the effects of operations research studies on manufacturing. Specific topics include: An operations research approach to budget control and reprogramming for the Air Materiel Command; Operations research in manpower scheduling and requirements forecasting; Economic lot-size determination in light of uncertain demand; Make-or-buy and source-selection decisions.

New Manufacturing Techniques — High-Energy Forming by C. W. Gipe,

Continued on next page

secretary. Discusses new high-energy manufacturing techniques such as electric arc forming, high-energy impact forming, and explosive forming.

Ground Support Equipment by J. R. Hughes, secretary. Discusses the economics side of GSE; component standards: economics of "off-the-shelf" components; configuration control and reliability: effect on GSE; manufacturing methods and quality control; use of design standards and MIL specs to insure economy of design and subsequent manufacture.

Handling of Propellants and Gases by D. H. Wayman, secretary. Up-to-date information on requirements, techniques, and procedures for the safe handling and usage of propellants and gases in manufacturing and testing processes. Specifically covered: handling of cryogenics, liquid and solid propellant testing safety techniques, contamination control of propellant systems, toxicology considerations, regulatory aspects of propellant handling, and training considerations.

New Manufacturing Techniques — Welding and Brazing by W. R. Roser, secretary. Advanced design concepts require advanced welding and brazing techniques directed toward integrity and producibility of complex structures. Discussion covers engineering design requirements and trends; fusion welding developments; brazing trends and status and potential applications of unconventional welding techniques.

Industrial Engineering by H. F. Murray, secretary. Covers evolution and predictions; value controls; simulation; cost projections; manpower utilization; and long-range planning.

Fabricating Refractory Metals by I. L. Schwartz, secretary. Fabrication of molybdenum, columbium, tantalum, and tungsten by forming, joining and coating. Discussed are: the producer's side of refractory metals; comparison of formability of refractory metals with other metals; forming and joining of molybdenum, tantalum, and columbium; fabrication of molybdenum and tantalum welded and brazed honeycomb sandwich structures; forming of tungsten and problems related to oxidation-resistant coatings for refractory metals; and operational sequence of fabrication of details and assembly of parts for the Dyna-Soar program.

New Manufacturing Techniques — Processing by J. W. Ramsey, secretary. The extreme importance of weight saving in the flying article — rather than cost alone — influences the processing. Covered are: Cleaning: How clean is clean? — printed circuit cleaning — removal of coatings — ultrasonic cleaning; Elevated temperature processing: distortion control — coatings vs. atmospheres; Protective coatings: ablative coatings — oxidation protection of refractory metals; Electroplating: emissivity control — specialized plating for high-temperature service.

Reliability by L. S. Franklin, secretary. The overall reliability job: Design consideration including prediction — analysis and test of design validity — product manufacture — verification of product and product function — product use. Reliability achievement techniques: Planning manufacturing processes and tools — insuring attainment of goals by maintaining discipline in product manufacturing and purchasing — verifying the product through extended quality control activity — auditing feedback of performance data and taking corrective actions. Methods for determining skills and providing motivation: Leadership attributes — skill certifications and special training — prime and subcontractor communication system — reliability indoctrination of employees. Organization: Effects of non-directed reliability program — management controls required — specific departmental task assignments (departments directly affected by reliability considerations) — examples of reliability organizations. Budget and contractual requirements.

Facilities Planning for a Changing Business by H. F. Bartling, secretary. Discusses long-range planning for a short-range market; evolution of long-range planning tools; planned flexibility in facilities planning; policy problems in capital planning; contractor's obligation in meeting government requirements; selling the R & D capital budget; and, an electronic company's requirement.

Data Processing Mechanizes Production Control by O. J. Wolla, secretary. Shop order preparation and release: Mechanized preparation of shop orders releases to shop only those orders which can and should be in work, and facilities incorporating changes. Mechanized reporting: Data collection systems speed flow of time and production data and reduce reporting costs. Status reporting and shortage analysis: Rapid analysis of production data smooths flow of production and minimizes expediting and follow-up. Priority scheduling and shop loading: Systematic determination of hottest jobs assures meeting schedule position and takes the guesswork out of shop loading. Production analysis and cost control feedback: Analysis of production results and cost data at the detail operation level gives meaningful comparisons of actual vs planned performance. Eonomic considerations of data processing in manufacturing applications: How much can we spend for data processing in manufacturing? Do these applications pay off? Future developments: The total system.

Handling of Radioactive Materials by R. K. Vance, secretary. Discusses licensing, regulation, and control; the health and medical aspects; facilities required and their planning, design, and construction; radioactive materials currently used by industry and future prospects; the fabrication and handling of uranium on a production basis; environmental control and regulation and local and state requirements.

New Manufacturing Techniques — Metal Removal by Ken Sparling, secretary. Discusses applications dictated by aerospace developments; chemical milling of advanced materials; electrical and electronic metal-removal methods; thermal machining; and ultrahigh-speed machining.

Electronics Manufacturing of the Future by A. W. LaMountain, secretary. Discusses: Reliability and its influence on methods and processes; packaging configurations and the limitations of personnel to produce; the work station and its required flexibility; automation, a mandatory requirement of the future; testing and the evolution of test equipment into process control; and, the production line of the future.

Thermal Treating Can Cause Distortion

Based on report by

W. C. ANDERSON

North American Aviation, Inc.

THE PROBLEMS of distortion and surface protection during heat treating are universal to all materials and become more critical in lightweight structures. The basic causes of distortion are heating, holding at temperature, and cooling.

The relief of residual stresses, differential temperature (too rapid a heating rate), and growth will cause distortion during heating. If the part does not have enough strength to support itself at the heat treat temperature, it will sag due to creep. On cooling or quenching, the more rapid the rate of cooling, the greater the distortion will be.

The differential temperature on heating can be eliminated by using a preheat, or by heat sink plates that are attached to the thin sections. These plates will reduce the temperature gradient between thick and thin sections. These heat sink plates will also reduce distortion during the quenching.

If a part is too weak to support itself at the heat treat temperatures, a fix-

ture is needed to control distortion. But a fixture adds to the problem, for to be effective they should be massive and this leads to difficulties in the cooling cycle. The ideal fixture is "one which heats up more slowly than the part it is holding (thus retaining more strength), does not itself distort, does not excessively retard the cooling rate of the part, and has more strength than the part during cooling."

During cooling, distortion can be controlled by using heat sink plates or by die quenching during the transformation. Die quenching is particularly adaptable to precipitation hardening stainless steels because of their low transformation temperatures. Distortion can be corrected during tempering by fixturing to size during the tempering cycle and allowing the part to creep to final dimension.

There is no single protective atmosphere for all metals. Many of the atmospheres that were suitable for low alloy steels are not satisfactory today. For example, a purified exothermic atmosphere with less than 0.5% combustibles has caused carburization of Rene 41 and PH 15-7Mo. The only truly inert atmosphere is dry argon or helium.

Many protective coatings will contaminate the surface of PH steels or nickel-base alloys. The coatings available for heat treatment are electroplated metals, metallic paints, reactive ceramic paints, and fused ceramic paints. These coatings have their advantages and disadvantages and proper laboratory tests should be made to verify the selection of a coating or an atmosphere.

(This article is based on a report of one of 14 aerospace manufacturing forum panels. All 14 are available as a package as SP-333. See order blank on p. 6.

Effect of Engine RPM on MEP and Fuel Economy

Based on paper by

B. J. Mitchell, G. P. Ransom, and H. E. Reed

Engineering Staff, GMC

FIGS. 1 and 2 show the effect of engine rpm on mep, power, and fuel economy, as revealed by GM's new 371 cu in. V-8 variable compression ratio test engine developed for the petroleum industry. The engine was designed to operate at compression ratios of 10/1, 12/1, and 15/1.

Fig. 1 shows mep curves for each ratio. Fig. 2 is a plot of horsepower and fuel economy variation with speed and compression ratio. Gains in fuel economy were consistent with the compression ratio increase. The friction horsepower also increased slightly with compression ratio increase, as expected, but the difference was not sufficiently large to show on the curve.

The LBT test used to obtain these results has these conditions:

1. Maximum power through the speed range.
2. Manually adjusted LBT (leanest for best torque) fuel rate, by eye.
3. Manually adjusted MBT (minimum for best torque) spark advance, by eye.
4. Air cleaner installed.
5. Minimum exhaust back pressures.

■ **To Order Paper No. 260A . . .** from which material for this article was drawn, see p. 6.

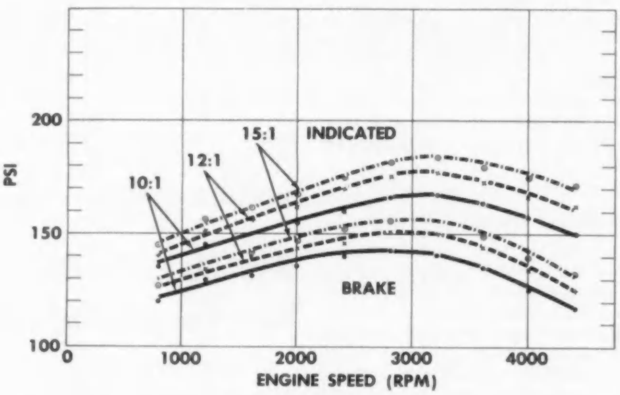


Fig. 1 — Mean effective pressure variation with speed for test engine at three compression ratios, with LBT fuel rate and MBT spark advance.

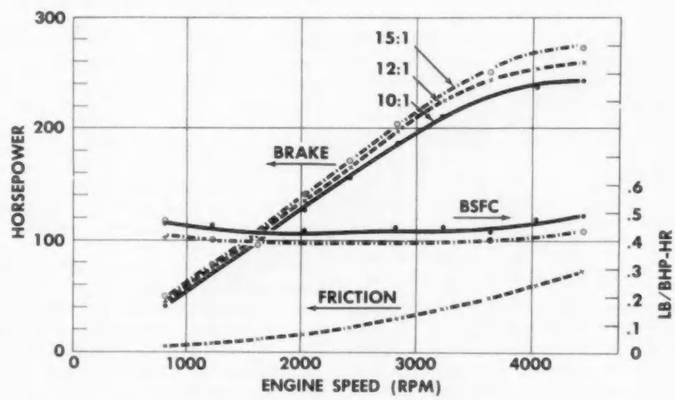


Fig. 2 — Power and fuel consumption variations with engine speed for three compression ratios.

Quantitative Aids Improve Part Quality

Based on report by secretary

L. S. FRANKLIN

Convair Astronautics

QUANTITATIVE measures must be used when controlling the quality of manufactured products. These range from the traditional statistical techniques to the more recently developed techniques of useful life, time-to-failure, mission of system; strength, accuracy, and safety margins; and derating methods.

Raw products being worked by humans will inevitably have imperfecti-

Continued on page 126

Airport Snow Problems Yielding to Attack

THE advent of the jet transport has aggravated the problem of slush, water, and snow on airport runways. Jets are more affected than propeller-driven aircraft by slush and water because of their higher landing and take-off speeds, and lower acceleration and deceleration characteristics on the ground. Less than 1 in. of slush can make take-off hazardous.

At the NASA Langley Research Center it has been found that different tire treads develop significantly different braking friction coefficients in slush at speeds up to 100 knots with a tire load of about 10,000 lb. This translates into marked differences in the distance required to bring an airplane to a stop on a wet runway.

Friction coefficients vary greatly according to the conditions of the runway and they may even vary along a single runway. On snow and ice-covered runways, the friction coefficient varies from 0.15 to 0.45. For every 0.01 change in this coefficient, the stopping distance of a 150,000-lb transport increases about 75 ft. Means need to be devised for determining the friction coefficient quickly and often and conveying the information in useable form to pilots.

Determining Friction Coefficient

In Sweden, various methods have been tried for obtaining the coefficient of friction, such as by skidding a truck to a stop and calculating braking action from time and distance, skidding a truck and recording deceleration with an accelerometer, and using a special trailer to give continuous registration of braking efficiency. All methods are good and local conditions determine their fitness. The trailer method has the advantages of taking less time on the runways and designating the exact spots for sanding. This cuts sanding costs and reduces the amount of sand lying around to damage engines through ingestion.

If the friction coefficient is known to the airport authorities, the information can be conveyed to pilots with a meaningful descriptive terminology, even to condition of runway sections.

Fast Snow Clearing

Clearing runways of snow, of course, is essential. The snow should be disposed of quickly when it is fresh-fallen and light. Plowing means repeated handling and is too slow for the jet age. In Canada, high-speed sweepers and blowers have been built which operate at a speed of 25–35 mph. The sweeper can whisk snow away, or can sweep water and slush from a path on the runway which an aircraft can follow on take-off or landing. By using steel bristles embedded in rubber, which wear out rather than break off, over 200 hr of service life have been obtained. When the snow has been swept to the edge of a runway it can be picked up and blown away in any direction by the snowblower which also travels at 25–35 mph.

The information in this article was derived from the following papers:

"Some Effects of Runway Slush and Water on the Operation of Airplanes, with Particular Reference to Jet Transports," by Walter B. Horne and Upshur T. Joyner, Langley Research Center, NASA (Paper No. 275A)

"Clearing Snow Off Runways at High Speed," by D. B. Rees, Dept. of Transportation, Government of Canada (Paper No. 275B)

"Determining and Reporting the Braking Qualities of Icy or Snow-Covered Runways," by Birger Holmer and Gunnar Antvik, Scandinavian Airlines System (Paper No. 275C)

To order any of above papers, see order blank on p. 6.

New Materials Require New Cleaning Techniques

Based on report by

J. P. GORDON

Douglas Aircraft Co., Inc.

With today's rapidly moving technology, the cleaning specialist is faced with stricter cleaning requirements, new materials to clean, and new cleaning compounds. He must determine how clean the part must be, what soils are present, and what new techniques will be required to accomplish the task. And, he must be able to translate the laboratory evaluations into a production process with control tests that can be performed by personnel with limited technical experience.

In this day of rapidly moving technology, so many new materials are being developed that in the field of cleaning many new processes are required. To solve these new problems, an exploration of the basic fundamentals of cleaning is a must. For example, in a particular case, the next process step or end use must be analyzed to determine how clean the part must be to perform its function.

Next, the prior processing must be examined to determine what soil (contaminant that affects the end use or next process) needs to be removed and what are its properties.

The cleaning specialist has six basic cleaning types to work with: alkaline cleaners, solvents, emulsions, acid etch cleaners, electrolytic action, and ultrasonics. From these basic types he can select the necessary cleaning process. (One method of evaluating the effectiveness of a cleaning material is by the addition of a measured amount of short-life radioactive ions to the soil and the measurement of the amount of radioactivity before and after the cleaning sequence.)

One of the new cleaning tools available is ultrasonics. In a process where the cleaning material required to do the job may be toxic to the personnel or harmful to the material, an alternate cleaning material may be used that has lower cleaning power, but by adding ultrasonics, the new combination will have adequate cleaning power. Also ultrasonics will clean very small crevices, and in some applications, it can be used for cleaning completed assemblies and eliminate the many hours that would have been required for disassembly, rubbing, soaking time, and reassembly.

A typical critical cleaning application that exists today is in printed circuitry where a high degree of cleanliness is required to minimize the tendency for 'plate-through' in the noncircuit areas.

In other cleaning operations, the rinse water must be controlled to obtain the required cleanliness. In cleaning for epoxy paint systems, the rinse water must be controlled to less than 80 ppm hardness expressed as Ca/-$MgCO_3$ and with the new, fast, air-dry catalyzed epoxy primer, the control of the rinse water is even more critical.

Still another critical cleaning requirement is in metal bonding where the cleaning may be satisfactory if the parts are to be bonded within a short time after cleaning, but time delays caused by multiple bonding operations or complex assembly operations can cause a serious loss of strength. Here the cleaning specialist must find cleaning methods that will hold the necessary cleanliness for a longer time or control the contaminants in the bonding area, such as humidity and dust.

Cleaning also includes the removal of applied coatings, and where the coating industry is developing excellent protective coatings with greater adhesion and better chemical resistance, these same coatings are more and more difficult to remove.

(This article is based on a report of one of 14 aerospace manufacturing forum panels. All 14 are available as a package as SP-333. See order blank on p. 6.)

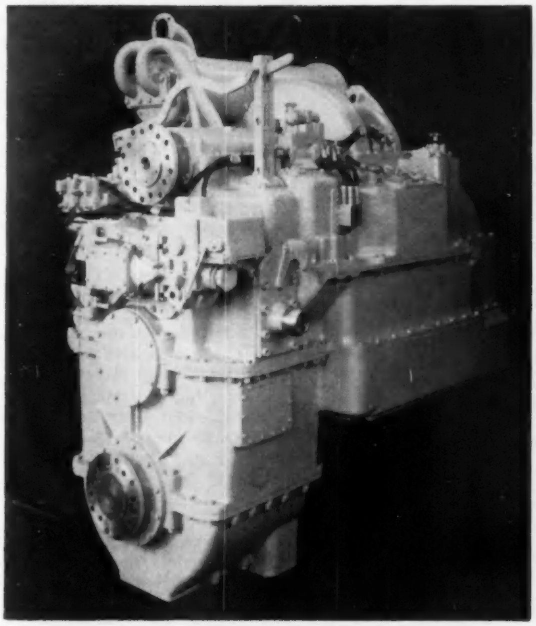


Fig. 1 — Voith hydraulic transmission for diesel locomotives. Efficiency over entire operating range is achieved by using three torque converters.

Hydraulic Transmission — A Feature of Diesel Locomotives on European Railways

Based on talk by

P. V. GARIN

Southern Pacific Co.

HYDRAULIC transmissions for diesel locomotives have been developed in Germany and are now in satisfactory use on the railroads of many European countries. Some designs use a combination of fluid coupling and torque converters; others employ only torque converters.

The torque converter has both good and poor characteristics for locomotive use. It provides the high starting torque so necessary for locomotive traction, but its efficiency drops off rapidly in the higher output speed ranges. To get around this basic difficulty, the Voith turbotransmission (Fig. 1) uses three converters. The first one is designed to produce the high starting torque up to its peak efficiency of about 83%. At this point a second converter comes into action to provide its portion of the tractive effort-speed range at its maximum efficiency. When its efficiency drops, the third converter comes into play at the high-speed range at the peak of its efficiency. The efficiency curve for this transmission is shown in Fig. 2.

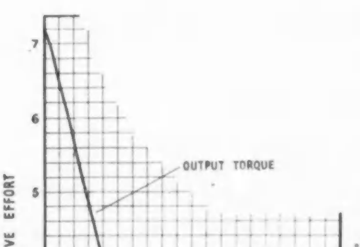


Fig. 2 — Multiple torque converter performance curves — output speed based on constant input speed versus efficiency and output torque — of Voith hydraulic transmission.

Another hydraulic transmission that has proved itself in European railway service is the Maybach Mekydro. It employs one torque converter and an overriding clutch to produce a 4-stage transmission with characteristics similar to the 3-stage Voith, and an equally acceptable performance.

The advantages claimed for hydraulic transmissions under European operating conditions (they are untried as yet in the United States) are:

1. A torque ratio that can reach values of more than 10/1.
2. Better use of adhesive weight on account of the higher factor of adhesion.
3. Continuous low-speed operation at full load without overheating.
4. Ability to exert full tractive effort at standstill without damage.
5. Lower unsprung weight on axles.
6. Smaller dimensions and lower weights of transmission and engine.
7. Simple operation and output adjustment.
8. Ease of maintenance and reduction of repair cost.
9. Protection against dust and water.
10. Reasonable transmission efficiency; equal to competitive units.
11. Permits use of hydrodynamic brakes.

Missile Age Calls for New Welding and Brazing Methods

Based on report by secretary

W. R. ROSER, Northrop Corp.

ADVANCED aerospace design concepts require advanced welding and brazing techniques directed toward integrity and producibility of complex structures.

Missiles and space vehicles are primarily pressure vessels and welded construction is best from the standpoint of efficiency and economy. The two major missile types — the liquid fueled Thor and the solid fueled Nike Zeus fall into the pressure vessel category.

Two types of weld joint construction are used in pressure vessels: one where the weld area is of a lower strength than the base metal due to size or distortion problems which prevent heat treatment after welding and require beefing-up to utilize the full base metal strength; and the other type which can be heat treated after welding so that the joint will approach the strength of the base metal.

Producing welds with high as-welded strength is a problem with the thickened-in weld design and occurs in all alloy systems. Development of welding techniques which permit 100% joint efficiency (so that failures do not occur in the weld) is a problem with the second type of weld construction.

Welded structures are becoming very important in manned high-speed aircraft due to the need for stiffened panels and sandwich arrangements. The problem of economically producing these to close tolerances is still acute. Joining of stiffened panels to achieve high efficiency, low distortion, and low residual stresses is a problem.

Refractory metal alloys and titanium alloys must be used in aerospace vehicles and many problems exist in the joining of these metals. The major problem is that of obtaining a deposit of sufficient purity, controlled grain size, and soundness.

Approximately 23,000 sq ft of brazed honeycomb sandwich is required on the exterior surface of the B-70 Mach 3 bomber and 6500 sq ft on the interior. The material used is PH15-7MO stainless steel and the facing sheets must be flat within 0.002 in.

Machining methods utilized to provide the core configuration required by complex shaped panels include electrical discharge cutting, electrolytic metal removal, disk cutters, hard wheel abrasive cutters, and abrasive belts.

Prior to brazing, the skins, core, and brazing foil must be completely clean and handled with white gloves to prevent contamination of the assembly.

Brazing is accomplished by the electric blanket method. The tool is composed of a castable fused ceramic material known as glass rock. The resistance heating of nichrome strips is used to bring the tool up to temperature and effect brazing and heat treatment. The cycle consists of heat-up to the brazing temperature of 1665 F, hold for 15 min, cool to room temperature, cool using liquid nitrogen to below −95 F and hold for 3 hr, followed by aging at 1075 F. The normal cycle takes 15 hr. Brazing is accomplished in a sealed retort under argon atmosphere.

Some panel brazing is accomplished in a salt bath. Here, the retorted assembly is brought to brazing temperature in the bath and placed in a press to get the desired flatness.

The joining of tubing is a problem in the B-70 and a brazed coupling which is induction heated to effect brazing is used. It is possible to use this coupling in cramped quarters and brazing can be done in the airplane 100 ft away from the induction generator through the use of coaxial cables.

The tungsten inert-gas process accounts for 90% of all fusion welding done in the aerospace industry. Product changes, however, necessitate constant improvements in welding processes. This is expected to result in the following trends; more welding will be done on the final assembly; assemblies will be larger; they will be less rigid; tooling must be tailored to the product; welding tooling and the product must be carefully integrated to the design facets; structures in general will be made of thinner gages.

Seven major variables are present in fusion welding: base material, filler material, joint design, power source, controls, gas shielding system, positioners, tools, and fixtures.

For welding to keep pace with aerospace hardware needs, continued attention must be given to the arc and its effects on the success of the overall system and its variables. More controls are needed and must be developed. Feedback information must be provided if performance is to be reliable.

Three of the newer welding techniques are ultrasonic welding, electron beam welding, and foil seam welding.

Ultrasonic welding has been used for specialized applications in the aerospace industry. The process can be used for spot, butt, and seam welding. The exact mechanism of ultrasonic welding is not known, but it is believed to be akin to a friction type of motion causing heating. Most of the applications of ultrasonic welding have been limited to aluminum; also it is limited to a maximum thickness of material. The greatest potential for ultrasonic welding appears to be in joining refractory metals or dissimilar metal combinations.

Electron beam welding is performed in a high vacuum which prevents contamination of the weld area. The two basic types of electron beam welders are electromagnetic focusing and electrostatic focusing. The process utilizes the energy of electrons emitted from a hot wire filament and accelerated by a high voltage and focused into a beam. The low voltage type of beam welder uses an accelerating voltage up to 20 kv and the high voltage type operates at 100–150 kv. With the high voltage equipment a high width-to-depth ratio of weld can be produced.

Foil seam welding is a process by which sheet material is joined utilizing foil resistance welded over the sheets. No overlap of the sheets is required and a smooth joint is produced.

Another promising process applies ultrasonic energy to the weld during solidification to effect grain refinement. Work has been done both in the U. S. and Russia. The results have not been conclusive but indicate that the process has promise. Major problem is that of introducing sufficient ultrasonic energy into a large part.

Serving on the panel which developed the information in this article, in addition to the panel secretary, were: chairman **A. P. Binsacca**, Northrop Corp.; co-chairman **J. L. Waisman**, Douglas — Santa Monica; **E. L. Stone**, Boeing Airplane Co.; **L. Frost**, North American Aviation; and **R. E. Monroe**, Battelle Memorial Institute.

This article is based on a report of one of 14 aerospace manufacturing forum panels. All are available as a package as SP-333. To order, see p. 6.

More Subsonic Planes Needed in the Future

Based on paper by

M. L. PENNELL, Boeing Airplane Co.

MANY MORE subsonic airplanes are going to be needed to satisfy demands of our expanding air transportation system.

The new aircraft will have much in common with today's jet transports. But they will incorporate significant improvements made possible by better powerplants, and by normal design evolution.

Eventually, also, we will need and have supersonic air transports — to satisfy our national prestige, if for no other reason. It would be better, however, if we wait until we can design and build an economically competitive airplane — which can take its natural place in American transportation.

In the meantime, continued aggressive and intelligent research will insure our being reasonably ready to build supersonic planes when they are required.

■ To Order Paper No. S278 . . . from which material for this article was drawn, see p. 6.

SAE NEWS

SAE Establishes a New ENGINEERING EDUCATION Activity

Philip S. Myers is EAB Sponsor for SAE's newly established Engineering Education Activity.

ENGINEERING EDUCATION gets a strikingly new emphasis as an exchange-of-ideas area in SAE with establishment of an Engineering Education Activity as an integral part of the structure of the SAE Engineering Activity Board.

EAB approval for the new Activity came at its January meeting in Detroit. Approval followed consideration of a report — made at the Board's request, by Philip S. Myers, professor of mechanical engineering, University of Wisconsin. Myers, a Board member, has been named EAB Sponsor for the new group, and is proceeding with development of personnel and organization of the new committee.

The Myers' report grew from some years of increasing interest among SAE members in fostering closer relations between industry-oriented members and the education areas symbolized by the nearly 800 SAE members who teach engineering in some 200 leading colleges and universities. (SAE has college-professor members in such widely scattered places as Switzerland, East Africa, England and Holland.) The impetus for greater SAE attention to industry-education relationships came originally from SAE members on engineering school faculties.

Once in action, the new Engineering Education Activity will stress the exchange of ideas and information between educators and industry engineers. Each will contribute their knowledge of their own conditions and needs. The aims: (a) To keep industry informed about trends in engineering education and how it can best utilize the product of those trends; (b) To keep engineering educators informed about industry's every-changing personnel needs; and (3) to provide a forum for discussion of subject of peculiar interest to those SAE members actively engaged in education and teaching.

"In developing its broad program," Sponsor Myers said following the new Activity's establishment, "I am sure the new committee will be found sticking to exchange-of-ideas as the objective of the papers and articles it generates. It will stress that same objective in suggesting to authors the approach likely to be most fruitful for both educators and industry-engineers.

"The highly successful January session titled, 'Breakthroughs in Engineering Education in the '60s' set a pattern, I believe, both in philosophy and procedures for the new committee," Myers continued.

"To begin with, the session was sponsored jointly by SAE and the American Society for Engineering Education, a group which includes our most distinguished engineering educators. And, I am confident, EAB hopes that its new Engineering Education Activity will seek and find ways for further fruitful cooperation with this representative education group.

"In other ways, too, this January session set a good pattern for the future. At that session, distinguished engineers from both education and industry contributed from their own areas mutually helpful ideas on many topics. Their discussion ranged over engineering education abroad; new trends in organizing engineering education; post-university-on-the-job training for engineers; and new trends in educating tomorrow's engineers. The panel was organized and guided by Dean K. F. Wendt of University of Wisconsin. It included Dean W. L. Everett, University of Illinois, and Dean G. S. Brown, Massachusetts Institute of Technology. From industry were E. J. Manganiello, National Aeronautic and Space Administration, and J. J. Mikita, technical manager of DuPont's Petroleum Chemical Division.

"Attendance at the session was so large as to point up dramatically the SAE interest in continuing such engineering education idea-exchanges. And audience participation was widespread and pertinent. It included penetrating comments by W. J. Ewbank, University of Oklahoma and Ray Darling, General Motors Corp.

"So," Myers concluded, "I think it is clear that the SAE Engineering Activity Board — in establishing this new Engineering Education Activity — has taken an action that is both timely and constructive."

Coder Directs Summer Institute In Engineering Sciences

CHARLES H. CODER, JR., (M'57) head of Bucknell University's Mechanical Engineering Department, directed the first "Summer Institute in Engineering Sciences" . . . conducted by Bucknell in Lewisburg, Pa., and sponsored by the National Science Foundation. A second Institute will be held under NSF sponsorship June 26 to Aug. 4, 1961.

Charles H. Coder, Jr.

At the 1960 Institute, 48 pre-engineering instructors from junior and liberal arts colleges attended basic science sessions in chemical, civil, electrical and mechanical engineering during the six-week seminar. The purpose: to raise the level of junior and liberal arts college pre-engineering curricula to enable their students to go on to earn engineering degrees from accredited colleges.

The Institute grew out of Bucknell's extensive survey into the apparent drop in accredited-college engineering enrollment in recent years. The survey showed that a large number of the country's 451 junior and 100 liberal arts colleges were offering pre-engineering courses . . . and that many students were enrolling in these schools because they were nearer home and less expensive. Pinpointed, however, as crux of the problem was lack of engineering education or experience on the part of many instructors teaching the 2-yr pre-engineering courses in these schools. . . . The Summer Institute was designed specifically to fill this need.

Careful screening eliminated applicants with advanced engineering degrees. Of the 48 participants, only 16 had engineering bachelor's degrees . . . and these latter were directed into In-

stitute courses outside the major studied.

Bucknell provided dormitory space where needed, as well as cafeteria, sports and many other University facilities for the six-week period.

In his report to the National Science Foundation on completion of the first Summer Institute, Coder recommended a continuation of the NSF grant, saying in part: "In view of the national need for more engineering graduates —and considering the expense of starting up new engineering schools — it becomes increasingly apparent that the junior and liberal arts colleges should be given every opportunity possible to commence pre-engineering programs and to improve on those already in operation."

FACTS . . .

from SAE literature . . .

SAE'S EXPANDED FACILITIES for publication of unabridged technical material are emphasized in a new 9-page booklet titled "Know Your SAE Publications."

The new Advances in Engineering Series and the Technical Progress

Series are described on pp. 5 and 6. SAE Journal, Transactions, Handbook, and Special Publications are described here briefly, too.

HOW SAE JOURNAL ARTICLES concentrate on engineering problems WHEN they are problems — and before they get into the news — is told on pp. 2 and 3 of the new advertising promotion booklet titled "SAE Journal's Editorial Story."

ENGINEERS WHO DEVELOP FUELS AND LUBRICANTS for ground and flight vehicles are told in outline — in the pamphlet titled "Fuels and Lubricants" — how SAE serves in this field.

. . . And the pamphlet titled "Powerplants" shows how SAE furthers powerplant technology through its meetings, technical committees, and publications.

Both pamphlets were prepared by the Engineering Activity Membership Program Subcommittee.

You'll . . .

be interested to know . . .

When JOSEPH G. HOBA (M'45) and J. URADNISHECK, JR. (M'58) were called upon to participate in school programs in their communities, they chose SAE's booklet "How to Get Your Job" as a means of helping the students — at the same time introducing them to SAE. About 55 students were involved in both programs.

Hoba conducted a "Senior Engineers Job Clinic" for Assumption University's first graduating class . . . and Uradnisheck coached a group of engineeringly-inclined high-school students in the various broad phases of engineering.

A NEW STUDENT BRANCH has been authorized at California State Polytechnic College — Kellogg-Voorhis Campus — in Pomona. Students held their first meeting as a club a little over a year ago . . . and start out as a Branch with 44 members. With authorization of the new Branch at Pomona, the College now has two SAE Student Branches . . . one in San Luis Obispo having been operating since June, 1949.

JOHN E. JORGENSEN, New England Section's secretary, had been closing his Governing Board minutes with a statement of the hour at which adjournment took place.

In a recent set of minutes, he accounts for deletion of the closing line as follows: "By popular request, I am no longer permitted to say at what hour the meeting adjourned. It seems that some of the members get so involved with Section problems, they spend several hours after the meeting discussing them!"

LISTING IN SAE'S MEN AVAILABLE BULLETIN brought one job seeker 27 inquiries — and to 21 others, ten or more each.

A survey for the last quarter of 1960 — from which the figures were taken — showed the average number of inquiries received per man to be 8½ for this period . . . and that every applicant listed received at least one response.

The former SAE Colorado Group became SAE's 42nd SECTION by virtue of SAE Board of Directors' approval at its January meeting. The NEW COLORADO SECTION started out with 131 members from the trucking, passenger car, utilities, communications, aerospace, petroleum, rubber products, and varied related manufacturing industries in this area.

TWO SAE SECTIONS — Twin City (in Minnesota) and Western Michigan — have been authorized by the Board of Directors to extend their territories as follows:

TWIN CITY — inclusion of the counties in Minnesota not previously in the Section's territory . . . as well as the Wisconsin County of Douglas; the North Dakota Counties of Cass, Grand Forks, Pembina, Richland, Traill, and Walsh . . . and the South Dakota Counties of Brookings, Codington, Deuel, Grant, Minnehaha, Moody, and Roberts.

WESTERN MICHIGAN — inclusion of Allegan, Barry, Ionia, Kalamazoo, Lake, Montcalm, Newaygo, and Van Buren in the State of Michigan.

FINK Named to SAE Board of Directors

FRANK W. FINK has been chosen a member of the SAE Board of Directors for 1961 to fill the vacancy created by resignation of A. A. Kucher to become 1961 SAE President. Fink was named by the Board of Directors at its January 13 meeting in Detroit.

The new Director is vice-president, chief engineer, electronic division manager, Ryan Aeronautic Co., San Diego, Calif. He served previously on the Board of Directors in 1948, 1949, and 1954; has been an SAE member since 1944.

John G. Moxey, Jr.

John G. Moxey, Jr. Heads SAE Technical Board for 1961

. . . eight new members appointed

JOHN G. MOXEY, JR. is 1961 chairman of the SAE Technical Board. He succeeds 1961 SAE President, A. A. Kucher, who chairmanned the Technical Board in 1960.

A meeting of the Technical Board on Jan. 12 preceded the Board's Award Luncheon where certificates of appreciation were presented to 18 engineers for their contributions to SAE Technical Committee work. Present at the meeting also were the eight new members of the Technical Board, whose terms run through 1963. (See photographs at left.)

Moxey assumes the Technical Board chairmanship after two previous years as a Board member, and 24 years experience in Society work. He is a Past SAE Director, a past chairman of the SAE Philadelphia Section, and has been a member of the SAE Publication Committee. He was long a member of the Fuels and Lubricants Activity Committee and has been active in various phases of the Coordinating Research Council.

A 1935 graduate of Swarthmore College in mechanical engineering, Moxey joined both the Sun Oil Co. and the SAE shortly after graduation. He started with Sun Oil in the Research and Development Department, and was successively assistant manager and manager of the company's Automotive Research Laboratory.

H. D. BARNES (M'50) is general manager of the Space-Ordnance Division, A. O. Smith Corp. . . . where he is engaged in the design, development, fabrication, and sale of missile cases, high strength spheres and containers for gases used in missiles and airplanes, and aeronautical components.

He started with A. O. Smith in 1926 as layout man and designer in the Chassis Frame Development Department. Later he became, successively, supervisor, Production Engineering Department; manager of the General Service Division; the Truck Chassis Frame Division; and the Bomb Division. He was director of defense products and atomic equipment when he acceded to his present position in April, 1960.

World War II interrupted his service with the corporation. He was with the U. S. Army from 1940–1945, and was released with the rank of Colonel.

C. V. CROCKETT (M'25) has been chief engineer of General Motors Truck and Coach Division since 1955. In 1924, with a B.S. degree in mechanical engineering, he started his automotive career in GM's Cadillac Motor Car Division as a lathe operator. In the succeeding years, he served as clerk in tool engineering; dynamometer operator; secretary of the Engineering Department; and staff engineer. His work at Cadillac took him into many fields, including patents, cooling, fuel, exhaust and electrical systems . . . and (during World War II) specialization on military tank armament. In 1950 he went to Cadillac's Cleveland Ordnance Plant as assistant chief engineer. There he became chief engineer in 1951 — where he remained until transfer to his present position in 1955.

In addition to his Truck and Bus Technical Committee service, he has been a member of SAE Truck and Bus Engineering Activity Committee. He is presently serving his Government on the Secretary of Defense's Advisory Panel on Ordnance, Transport and Supply.

ERNEST P. LAMB (M'34), Chrysler's executive engineer for administration, took foothold in the industry 35 years ago in Truck Division of

Packard Motor Car Co. He has seen service with Central Axle & Gear, Ford, and Studebaker — and was with the original Dodge Brothers in 1927 where he was employed as draftsman. He is presently a member of Chrysler's Engineering Executive Committee and of the Board of Trustees of its Institute of Engineering. He attended Detroit Institute of Technology.

Lamb is a member of the SAE Sections Board, and a past SAE Director. He has served as chairman for four years of the L. Ray Buckendale Lecture Committee . . . and was chairman of Detroit Section for the 1948–1949 Section year.

H. O. MATHEWS (M'31), as Armour & Co.'s general manager of transportation and distribution, is responsible for all traffic matters, warehousing and distribution planning as applied to chemical and packing-house products. He has been with Armour since 1951. His earlier experience, after graduation from Purdue University as a chemical engineer, was in plant engineering for Illinois Bell Telephone Co.; automotive engineering with Public Utilities Engineering and Service Corp.; and maintenance engineering with the Ordnance Department. Following World War II, he was automotive engineer for Standard Brands, and later transportation manager. He is a past SAE Director.

V. G. RAVIOLO (M'42) is executive director of Ford's Engineering Staff. Since starting with Ford in 1940, he has been executive engineer in charge of engine engineering; director of Lincoln-Mercury car engineering; and director of advanced product study and engineering research. In 1932 he started in the industry as draftsman for Chrysler. He later worked on vehicle design for Packard, and in research for Consolidated-Vultee. Long active in CRC's fuel and engine research, he has served the Technical Board as a member of its General Standards Council . . . and last year was appointed for a 3-yr term to SAE Engineering Activity Board, where he chairmans its Publications Advisory Committee.

Since 1943 **CHANDLER C. ROSS** (M'45) has been vice-president of engineering for Aerojet-General Corp. He received his B.S. in mechanical engineering from University of California at Berkeley, where he returned in 1942 as faculty and project engineer. Prior to his association with Aerojet-General, Ross was research engineer with the U.S.A. Corps of Engineers . . . and later, successively, chief engineer with Western Pump Co., chief engineer, Advanced Pump Co., and design engineer, Austin Co.

Ross has served SAE on the Technical Board's Aerospace Council and as a member of the 1960 Coordinating Research Council Board of Directors.

E. S. ROWLAND is chief metallurgical engineer at Timken Roller Bearing Co. His career began in 1933 as an instructor at Pennsylvania State University. Two years later he joined Timken, where his time was mostly devoted to research and development. He assumed his present position in 1952.

Outstanding among his services for SAE has been his work on the Iron and Steel Technical Committee, which he chairmanned in 1959, and his work on ISTC's Division 4 on Residual Stresses, of which he was also chairman. In 1960, he was a member of the Engineering Materials Activity Committee.

As Director of Engineering for Lockheed's California Division, **J. B. WASSALL** (M'39) is in charge of a workforce of several thousand . . . which is now implementing Lockheed's recently diversified program leading into many fields, including spacecraft. He started with Lockheed in 1937 when most of the corporation's activity related solely to aircraft. Prior to 1937, Wassall was with Beech Aircraft as assistant chief engineer. For SAE, in addition to Technical Committee service, he was a member of SAE Aircraft Activity Committee from 1954–1958.

Barnes

Crockett

Lamb

Mathews

Raviolo

Ross

Rowland

Wassall

SAE MEMBERS

GEORGE E. SPAULDING, JR. has been elected to the newly created post of vice-president in charge of engineering operations, Photo Products Division, Bell & Howell Co. Formerly associated with Electric Autolite Co., Spaulding served there as director of research and general manager of the SPARD Division.

THOMAS R. CONWAY has become development engineer — Chemical Processing Equipment Division, The Patterson-Kelley Co., Inc., East Stroudsburg, Pa. Formerly he was product engineer for Adsco Division, Yuba Consolidated, Buffalo, N. Y.

J. F. BLAMY has been appointed manufacturing manager, Pontiac Division, General Motors Corp. He was formerly director of reliability.

H. A. C. ANDERSON succeeds **Blamy** as director of reliability. He was formerly general superintendent, Pontiac Division, General Motors Corp.

T. C. CONNOR, formerly senior design engineer at Rocketdyne Division, North American Aviation, Inc., has established himself as a consulting engineer on aerospace and mechanical engineering problems at 16246 Kentucky Ave., Detroit, Mich.

Changes at . . .

North American Aviation

Atwood

J. L. ATWOOD, president, has been named chief executive officer of North American Aviation. **J. H. Kindelberger,** chairman of the board since 1948, asked the board to name Atwood to the chief executive officer position.

Kindelberger

Kindelberger, who will remain a full time operating officer of the company as chairman of the board and executive commitee, said the change will permit him to devote more time to broad policy development and planning.

DR. DONALD N. FREY has been appointed product planning manager, Ford Division of Ford Motor Co. Frey was formerly assistant chief engineer for their Ford and Mercury product engineering office.

TADAMASA YOSHIKI, Vice President, General of the Society of Automotive Engineers of Japan, delivered a lecture on fluid filtration at ULCA on February 2. Yoshiki was an Official Delegate from his society at the SAE International Congress and Exposition of Automotive Engineering in January. In addition to being an automotive engineer, he is a recognized authority in chemistry and metallurgy in Japan.

A. JOHN ST. GEORGE has been appointed manager of planning and administration at American Bosch Arma Corp. St. George has been associated with American Bosch Arma Corp. since the company acquired the Ensign Carburetor Co. of Fullerton, Calif. and the two subsequently merged. He was formerly Ensign product manager for the American Bosch Arma Commercial Sales Division.

ROBERT M. FLANAGAN has been named chief engineer at Rotron Mfg. Co., Inc. He was formerly manager product development, Stratos Division, Fairchild Engine & Airplane Corp.

St. George

Flanagan

LEROY R. BARR has been appointed general manager of Lear-Romec, Division of Lear, Inc. Barr will assume his new position following the retirement of **H. C. Andrus**, vice-president and present general manager of Lear-Romec. Barr was formerly assistant general manager of the company.

BENJAMIN G. GRAY has become instructor, automotive and diesel technology at Wilson Industrial Education Center. He was formerly an automotive engineer for Texaco, Inc.

SHERMAN C. HETH has been elected vice-president of engineering for the Jacobsen Mfg. Co. Heth was formerly director of engineering. He is a past SAE director.

F. T. HARRINGTON has been made vice-president-marketing of The Foote-Burt Company. He was formerly vice-president, Vickers, Inc., Division, Sperry Rand Corp.

DALE McCORMICK has been named administrative assistant for the vehicle development department of General Motors Corp. He was formerly administrative engineer of the department.

MAX RUEGG, formerly assistant engineer-in-charge, structure & suspension department, General Motors Corp. has been made executive asssistant engineer-in-charge of the department.

LAWRENCE KEHOE, formerly administrative engineer, has been made administrative assistant of the structure & suspension department of General Motors Corp.

JOHN ROSENKRANDS and WILLIAM McINTYRE have both been made assistant engineers-in-charge, structure & suspension department of General Motors Corp. Rosenkrands had been serving as assistant chassis suspension design engineer and McIntyre was experimental engineer of the department.

GEORGE C. HARBERT has been appointed chief engineer for Industrias Kaiser Argentina. Formerly he was chief engineer at Willys Motors, Inc.

DONALD B. SMITH has been appointed manager of procurement at Thompson-Ramo-Wooldridge, Inc. He was formerly manager, R&D — Automotive for TRW, Inc.

SAE FATHER & SON

Andy Lenz

Ronald Lenz

RONALD LENZ (right) is shown with his father, **ANDY LENZ**, a member since 1945. The senior Lenz is project engineer for the Products Division of Sinclair Research Laboratories. An employee at Sinclair Research Laboratories since 1930, Lenz has worked with various projects including volatality and octane requirement programs of cars on the road. During World War II a large portion of his time was devoted to military functions under the supervision of CRC. These programs included starting tests on U. S. Army Combat Tanks and other tests for Ordnance covering all types of ground vehicles. His present position involves supervision of engine-dynamometer testing of motor fuels and lubricants.

RONALD LENZ is a 1960 graduate of Purdue University with a BS in Electrical Engineering. He is presently employed with Boeing Airplane Co., Aero-Space Division, Seattle. He was an SAE Enrolled Student throughout his college career.

CHARLES M. WRIGHT has been appointed executive director at Helical Washer Institute. Formerly he had been staff engineer in charge of standardization for Chrysler Corp.'s Engineering Division.

ARNOLD B. MEDBERY has been appointed divisional analyst for Herman Nelson Division, American Air Filter Corp. He was formerly manager of engineering, aero-space products, Stewart-Warner Corp.

GERALD E. MINTZ has been chief engineer of Mack Trucks' newly created advanced engineering department. He was formerly chief engineer-buses and as a part of his duties he will continue to direct all the engineering divisions' bus activities.

THEODORE W. BAYLER, formerly reliability coordinator for Chrysler Corp.'s Missile Division has become reliability and quality assurance manager at Atlantic Research Corp.

PERRY W. HOUSE has been appointed works manager of the Delco-Remy Division of General Motors Corp. House was formerly manufacturing manager at Delco-Remy's ten Anderson plants.

ROBERT L. KESSLER has been appointed works manager of General Motors Corp.'s Buick Motor Division. He served General Motors formerly as works manager of their Delco-Remy Division.

P. R. JUK has been appointed to the position of assistant chief engineer — truck body at Chrysler Corp. Formerly he was manager of light truck chassis at Chrysler.

H. R. PICKFORD, formerly assistant chief engineer of heavy trucks has now been assigned all responsibility of truck chassis activities for Chrysler.

WILIAM B. GREELEY, formerly chief of maintenance, for the New England Storage Warehouse Co., has become vice-president of Griphoist, Inc.

MURRAY BURNSTINE has become an automotive engineer assistant in legal medicine for Harvard Medical School — Department of Legal Medicine. He was formerly a research assistant at Wayne State University — Department of Neurosurgery.

Barr

Gray

Heth

Harrington

Continued on page 134

Rambling through the Sections . . .

SAE **Baltimore Section** will sponsor a **joint Army-Navy Meeting** at **Aberdeen Proving Ground,** Md., **April 13, 1961.**

It will be an automotive meeting, with military engineers presenting technical papers throughout the day. Industry participation is invited and panels will be available to answer questions regarding military testing procedures.

Registration	9:00 a.m.
Military and Civil Service Personnel	$5.00
SAE Members and Guests	7.50
Round trip bus from downtown Baltimore	2.50

Technical Meetings, Army	10:00 a.m.
Lunch and Tour of Museum	12:30 p.m.
Technical Meetings, Navy	2:30 p.m.
Tour of Automotive Facilities	4:45 p.m.
Social Hour	5:45 p.m.
Dinner	6:30 p.m.
SAE President's Address	8:00 p.m.

Reservations will not be accepted without accompanying checks. No reservation can be accepted after April 6. Reservation fee includes lunch, social hour, and dinner. Mail reservations and checks to:

George A. Bamford
Box 65 C, Phoenix, Maryland

TWO SAE FACULTY ADVISORS received certificates in appreciation of their contribution to SAE at the December meeting of **FORT WAYNE SECTION.** They were **Prof. Howard A. Macklin** of Indiana Technical College (second from left) and **Prof. Ramsey R. Jackson** of Tri-State College (second from right). Prof. Macklin has been faculty advisor for six years, and Prof. Jackson for seven years.

Making the presentation are Section Chairman M. J. Slater (left) and Student Activities Chairman Robert McAfee (right).

CERTIFICATES for 25 year membership in SAE were presented to (left to right): R. M. Mock, chairman of executive committee, Lear, Inc.; Commander Harlan K. Perrill, USN (RET.), supervisor of technical and planning, Lockheed Aircraft Service-Overseas, Inc.; Kenneth M. Brown, research engineer, Douglas Aircraft Co., Inc.; Wellington E. Miller, automotive engineering consultant, and Everett V. Allen, member of technical staff, Hughes Aircraft Co. at **SOUTHERN CALIFORNIA SECTION** on November 4.

"THE FIRST SILENT CABIN AIRCRAFT" — This is the term which has been applied to the French-built Caravelle, by those who have traveled in it. The 500 mph jet airliner, which will be used by United Air Lines for short hauls in 1961, features two jet engines mounted on the fuselage. The plane has a capacity of 64 passengers, weighs three tons and is powered by two Rolls Royce Avon 532R engines. Fuel capacity is 5,020 gal. This compares to a seating capacity of 109 passengers, a weight of 6¼ tons and a fuel capacity of 17,600 gal for the DC-8. The DC-8 cruises at 550–575 mph while the Caravelle cruises at 500 mph, Percy A. Wood, assistant vice-president of United Air Lines stated at a joint meeting of **NORTHERN CALIFORNIA SECTION'S SOUTH BAY and STOCKHOLM-SACRAMENTO DIVISIONS.**

THE DYNASPRAY, a new no-air paint spray apparatus, and the Centroiler, a recent development in compact centralized lubrication systems, were displayed by Lincoln Engineering Co. at **ST. LOUIS SECTION** on December 13. The display was one of five parts to the program, the subject of which was "What's New in Your Line?"

Five St. Louis firms provided displays of new items and equipment they are providing for the automotive industry, some of which included: uniseal piston ring combination and a new Teflon seal for rotating shafts displayed by Ramsey Corp.; and a liquid cooled disc brake soon to be installed on LeTourneau-Westinghouse equipment displayed by Wagner Electric Corp.

TRANSPARENT STEEL, electroluminescent lighting, and all metal tires are about the only features not incorporated in the Pontiac Tempest, Robert Knickerbocker of the Pontiac Division stated at **PITTSBURGH SECTION** on November 22.

THE PRECISION FUEL INJECTION SYSTEM is the most important, but least known characteristic of the diesel engine, John C. Campbell of General Motors Corp.'s Diesel Engine Division stated at **METROPOLITAN SECTION.**

This system controls diesel fuel consumption under varying loads in far closer proportion to work done than the carburetion systems of other type engines. Reports show that under part-load or idling conditions diesel operating costs are often cut in half.

PROF. MICHAEL GUIDON III (right) received a certificate in appreciation of his work as faculty advisor to the SAE Student Branch at the University of Washington, at the December meeting of **NORTHWEST SECTION.** Prof. Guidon is associate professor of mechanical engineering at the university and has been faculty advisor since the Student Branch received its charter in 1951.

Section Chairman Louis Schroeder (left) made the presentation.

SAE Members from Pennsylvania to Canada attended the largest meeting ever conducted by **SYRACUSE SECTION** on December 6.

SAE 1960 President Harry E. Chesebrough, who is shown above with Syracuse Section Chairman Richard A. Sturley of Carrier Corp., spoke on "The Challenge of Individualism."

Section Meetings

NORTHERN CALIFORNIA

March 1 . . . Professor Dale Hutchison, Stanford Research Institute. Joseph Coons, chief enforcement officer, Air Pollution Control District. "The Causes & Cure of Non-Automotive Smog." Claremont Hotel, Berkeley. Dinner 7:00 p.m. Meeting 8:00 p.m.

ST. LOUIS

March 14 . . . Annual Student Night, featuring paper contest between Student Branches at Parks College of Aeronautical Technology and Missouri School of Mines and Metallurgy. Meeting to be held at Missouri School of Mines & Metallurgy, Rolla. Dinner 7:00 p.m. Meeting 8:00 p.m.

SOUTHERN CALIFORNIA

March 13 . . . D. L. Pastell, head, engineering division, E. I. du Pont de Nemours & Co. "New Anti-Knock Compounds for Modern Gasolines." Rodger Young Auditorium, 936 W. Washington Blvd., Los Angeles. Dinner 6:30 p.m. Meeting 8:00 p.m.

SOUTHERN NEW ENGLAND

March 2 . . . B. Hawkins, public relations. J. Ryan, test pilot, Gyrodyne Co. of America. "The Small Helicopter." Bradley Field, Windsor Locks, Conn. Dinner 6:45 p.m. Meeting 8:00 p.m.

TEXAS

March 9 . . . Z. Arkus Duntov, chief designer of high performance cars, Chevrolet Motor Division, GMC. "Sports Car Racing in Europe." The Torch Restaurant, 3620 W. Davis, Dallas. Social Dinner 6:30 p.m. to 7:30 p.m. Meeting 8:30 p.m. Special Feature: Mr. Duntov will show movies of sports cars recing in Europe.

WILLIAMSPORT

March 6 . . . John S. Wintringham, research advisor, Ethyl Corp. "Potential Passenger Car Powerplants." Moose Auditorium. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Feature: Tour of Lycoming Division, AVCO.

METROPOLITAN SECTION — March 9,1961

Henry Hudson Hotel, 57th St. & Ninth Ave.

T & M and PASSENGER CAR

"New Attitudes and Concepts in Motor Vehicles"
Ray J. Potter — *Ford Motor Company*
30,000 Mile Project"
John Z. DeLorenn — *Pontiac*
"The Pontiac Tempest"
Dr. R. Burton Power — *Tung-Sol Electric, Inc.*
"Further Developments in Transistorized Ignition"

F & L and DIESEL

"Fuels for the Sixties"
W. D. Dukek — *Esso Research & Engineering Co.*
"Supersonic and High Energy"
Earl J. Gray — *Consultant* — *Ethyl International*
"Distillates
Thomas DeMuth — *Atlantic Refining Company*
"Gasolines"

AEROSPACE and AIR TRANSPORT

"Corporate and Short Range Jet Transport"
R. Bergeson — *Ford Motor Company*
"Need and Market"
A. B. Croshere — *Douglas Aircraft*
Paper by: E. F. Burton and A. B. Croshere
"Economics of Short Range Commercial Jet Transports"
Albert Brown — *Federal Aviation Administration*
"Problems of Airways with Commercial Jet Transports in Service"

Dinner Price: $6.50 members, $7.50 non-members

SAE LETTERS FROM READERS

From:

Robert Cass (M'39)
School of Engineering
University of Portland
Portland 3, Ore.

Dear Editor:

In the November issue of SAE Journal, you presented some subject matter of a McGraw-Hill published book dealing with writing reports (p. 75).

It was excellent and we were wondering here at the University whether it would be possible to obtain reprints of those pages as they would be excellent handouts to our engineering students.

I continue to be impressed by the excellence of the Journal. . . . It would be hard to find its equal anywhere. It is a real quality product and you and your staff must be very proud of it.

(Ed. note: Tyler Hicks' article, "How to Write Reports that Get Read," has been made into an SAE Special Publication (SP-189) available to members at 50¢ a copy ($1 to nonmembers) — with quantity prices available on request.)

From:

L. E. Fuller
Linde Co.
Division of Union Carbide Corp.
Indianapolis, Ind.

Dear Editor:

I was pleased to see the article "Wear Tests Spot Best Mating Materials" on pages 60–65 of the December, 1960, issue of SAE Journal. This article was based on my paper Number T43.

In transposing the paper to the Journal article two important typographical errors were made. The first is in the table of composition of materials on page 62. Correct composition of LW-I is tungsten carbide with 6 to 8% Co (cobalt): not Cr (chromium). The second error is in equation (7) on page 64. An = sign just after the fraction was omitted. The correct equation is:

$$K = \frac{4260hp}{6 \times 10^6} = 7.1 \times 10^{-4} \times h \times p$$

I hope that this errata can be brought to the attention of your readers in the next issue of the Journal.

(Editor: You're right and we're sorry. The composition and condition of material LW-1 should read: Linde flame-plated coating, tungsten carbide with 6–8% Co, ground and lapped.)

NORTHWEST Sets April 26 for special A.T. MEETING

SAE NORTHWEST SECTION has set April 26 as the date for its Special Air Transport Meeting this year. The program will run all day and evening, and will include a dinner. The meeting will be held in Seattle, Washington — as was last year's.

Scheduled for discussion are such timely problems as:

- In-flight Air-Collision Avoidance
- Jet Airtransport Economics
- STOL Design Progress and Possibilities
- Governmental Research Progress
- All-Weather Flight Possibilities.

National authorities have been invited to present their views.

Section vice-chairman for Aircraft Ben F. Dotson issues a special invitation to the meeting to SAE members from all other sections to attend. He will be glad to hear from any SAE member who wishes more detailed information about the sessions.

SAE NATIONAL MEETINGS

- **March 13–17**

  National Automobile Week (Combined National Automobile and Production Meetings), The Sheraton Cadillac, Detroit, Mich.

- **April 4–7**

  National Aeronautic Meeting (including production forum and engineering display), Hotel Commodore, New York, N. Y.

- **June 5–9**

  Summer Meeting, Chase-Park Plaza, St. Louis, Mo.

- **August 14–17**

  National West Coast Meeting, Sheraton Hotel, Portland, Ore.

- **September 11–14**

  Combined National Farm, Construction and Industrial Machinery; Powerplant; and Transportation Meetings (including production forum and engineering display), Milwaukee Auditorium, Milwaukee, Wis.

- **October 9–13**

  National Aeronautic Meeting (including manufacturing forum and engineering display), The Ambassador, Los Angeles, Calif.

- **November 9–10**

  National Fuels & Lubricants Meeting, Shamrock Hotel, Houston, Texas

25,000

Break All SAE Records

RECORD-BREAKING characterized every phase of the SAE International Congress and Exposition of Automotive Engineering at Detroit's Cobo Hall, January 9–13. Attendance totalling over 25,000 outdistanced that of any previous SAE meeting . . . by well over 300%.

More papers, more committee meetings, and more technical discussion than ever before also combined to make this 1961 SAE Annual Meeting the greatest as well as the largest in the Society's 56-year history. The Engineering Display, in which more than 200 exhibitors showed the technical aspects of the latest automotive and aerospace products, was also the largest ever held by SAE. . . . And the foreign engineers in attendance brought about the most fruitful exchange of engineering information and ideas.

While the international delegates and authors were the center of attention on every day of the sessions, conduct of the Society's official business went forward as usual, and domestic as well as international problems were attacked as usual.

The Annual Business Session of the Society was held this year at the very beginning of the meeting — preceding the opening of the technical sessions on Monday morning. 1960 SAE President Harry E. Chesebrough presided; the Society's Annual Report for 1960 was submitted to the members and approved; and SAE Secretary and General Manager Joseph Gilbert read the results of the election of officers for 1961. (The nominees listed in the September, 1960, SAE Journal were all elected.)

Among the more than 100 administrative and technical committee meetings held were the opening 1961 sessions of the SAE Board of Directors, the SAE Engineering Activity Board, the SAE Technical Board, and the SAE Sections Board. 1961 SAE President A. A. Kucher presided at the meeting of the 1961 Directors. 1961 chairman of the Engineering Activity Board is J. T. Dyment of Trans Canada Airlines; of the Technical Board, John G. Moxey, Jr. of Sun Oil Co.; and of the Sections Board, Paul F. Allmendinger, Stewart-Warner Corp.

W. K. Creson, SAE President in 1958, was the recipient of an Honorary Membership in the Society, on the occasion of his completion of two years as a member of the SAE Board of Directors following his presidential term.

HIGHLIGHTS OF THE MEETING were the International Luncheon at which the principal speaker was Paul G. Hoffman, managing director, United Nations Special Fund, and the International Banquet (the 1961 SAE Annual Meeting Dinner) at which General Motors' President John F. Gordon (right), was the chief speaker. (See p. 108 for story of the Banquet; p. 111 for story of the Luncheon.)

SAE President Entertains

Harry E. Chesebrough, 1960 SAE president, and Mrs. Chesebrough were hosts at a reception and dinner for the official delegates from foreign engineering societies and their ladies on Sunday evening, prior to the opening of the formal technical program on Monday.

H. L. Brownback, chairman of the President's International Reception Committee, joined President Chesebrough in this opening welcome to the visitors at the Sheraton-Cadillac Hotel.

Among those attending were . . .

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1960 SAE President and Mrs. Harry E. Chesebrough

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1. 1961 SAE President A. A. Kucher; Mrs. Eiji Toyoda; Mrs. A. A. Kucher; and Mr. Eiji Toyoda, president, Society of Automotive Engineers of Japan.

2. Dr.-Ing. Wifredo P. Ricart, honorary president, Sociedad de Técnicos de Automocion (Spain); Prof. Dr.-Ing. Paul Koessler, president, Verein Deutscher Ingenieure, Fachgruppe Fahrzeugtechnik (West Germany); and 1960 SAE President Chesebrough.

3. Mr. Birger Holmer, official delegate, Föreningen För Skeppsbyggnadskonst (Sweden); Mrs. George Langham; Mr. George Langham, president, The Institution of Automotive and Aeronautical Engineers (Australia); and Mr. Nils E. Nyström, official delegate, Mekanik, Svenska Teknologföreningen (Sweden).

4. Mr. Charles Luttman, secretary, Canadian Aeronautical Institute; Dr. A. M. Ballantyne, secretary, The Royal Aeronautical Society (England); Dr. E. S. Moult, president, The Royal Aeronautical Society (England).

5. Mrs. Charles Luttman; Mr. Charles Luttman, secretary, Canadian Aeronautical Institute.

6. Mr. W. M. Heynes, Automobile Division chairman, The Institution of Mechanical Engineers (England); Mr. Reginald Main, assistant secretary, The Institution of Mechanical Engineers; and Mrs. Donat Gauthier.

7. Past SAE President Leonard Raymond; Mrs. W. P. Ricart; Mrs. Leonard Raymond; and Dr.-Ing. Wifredo P. Ricart, honorary president, Sociedad de Técnicos de Automocion (Spain).

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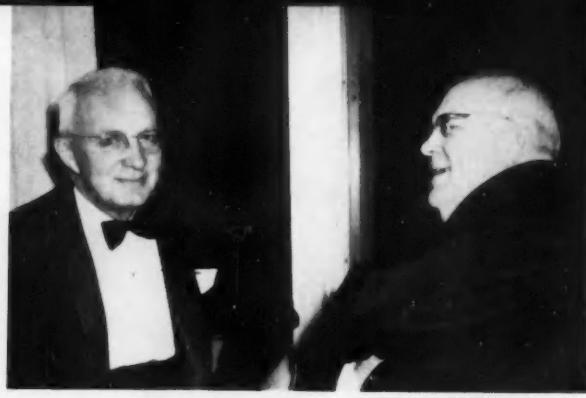

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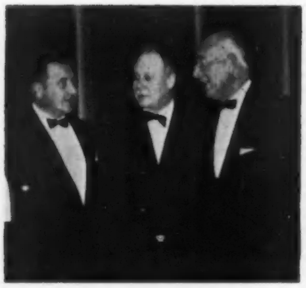

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Foreign Delegates

1. Nils E. Nyström (center), official delegate, Mekanik Svenska Teknologföreningen (Sweden) and Birger Holmer (right), official delegate, Föreningen För Skeppsbyggnadskonst (Sweden).

2. Paul Ackerman, chairman, Congress Operations Committee, and SAE Past-president J. C. Zeder.

3. Henry W. Goodinge, assistant director, Society of British Aircraft Constructors, Ltd.; and Reginald Main, assistant secretary, Institution of Mechanical Engineers (England).

4. Henry Ford, II, president, Ford Motor Co.; E. D. Gray-Donald, official delegate, Engineering Institute of Canada; and 1961 SAE President A. A. Kucher.

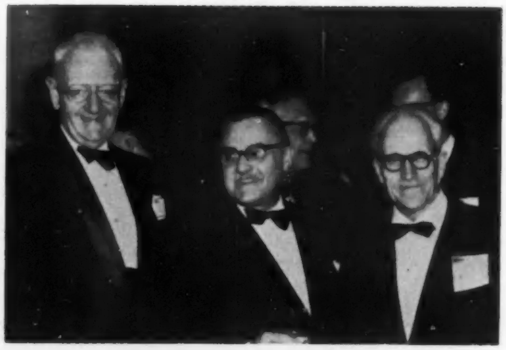
5. Dr.-Ing. J. S. Meurer, official delegate, Verein Deutscher Ingenieure, Fachgruppe Fahrzeugtechnik (West Germany).

6. Aimé Fourgeaud, official delegate, Société des Ingénieurs de l'Automobile (France); Herman Bosch, official delegate, Koninklijk Instituut Van Ingenieurs (Holland); and Prof. Antonio Capetti, vice president general, Associazione Tecnica Automobile (Italy).

7. 1960 SAE President Harry Chesebrough; Fernand Picard, president, and Robert Geffroy, secretary general, Fédération Internationale des Sociétés d'Ingénieurs des Techniques de l'Automobile (France).

8. C. A. Chayne, past SAE director; W. M. Heynes, Automobile Division chairman, Institution of Mechanical Engineers (England); and Prof. Dr.-Ing. Paul Koessler, president, Verein Deutscher Ingenieure, Fachgruppe Fahrzeugtechnik (West Germany).

9. Lt. Gen. A. G. Trudeau and William Byrne, president of the American Society of Mechanical Engineers.



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THROUGHOUT THE MEETING, foreign delegates and visitors exchanged ideas and information with the United States engineers in hundreds of informal conversations as well as at the technical sessions. Many such interchanges took place at receptions preceding the International Luncheon (held Tuesday) and the International Banquet (on Wednesday) . . . as well as every day in the International Lounge. These pictures on pp. 104–107 inclusive show many of these exchanges taking place.

SOME THIRTY distinguished multi-lingual SAE members assisted Chairman H. L. Brownback of the International Reception Committee to give the scores of visiting foreign engineers both a fruitful and enjoyable experience in their attendance at SAE's International Congress. . . . The Committee and its chairman made the foreign visitors welcome at a suite in the Sheraton-Cadillac and in Cobo Hall.

MEMBERS OF THE INTERNATIONAL RECEPTION COMMITTEE were: H. L. Brownback, chairman; Frank W. Fink, Ryan Aeronautical Co.; Tore Franzen, Donat A. Gauthier, Overseas Engineering Service; Emil F. Gibian, Thompson-Confap-Companhia Fabricadora de Pecas; E. N. Hatch, director of Franchises, Nassau County, N. Y.; Charles M. Heinen, Chrysler Corp.; Gunnar H. Hemstrom, General Motors Corp.; George H. Joly, Ford Motor Co.; SAE Past-President William Littlewood, American Airlines; Karl Pfeiffer, Chrysler Corp.; SAE Past-President Leonard Raymond, Socony Mobil Oil Co.; T. B. Rendel, Shell Oil Co.; SAE Past President C. G. A. Rosen, Prof. H. K. Sachs, Wayne University; A. C. Sampietro, consultant; Giovanni Savonuzzi, Chrysler Corp.; F. Herbert Sharp, Convair; T. L. Swansen, Ladish Corp.; A. F. Underwood, General Motors Corp.; Ernest Werner, General Motors Corp., and Otto Johann Winklemann, Chrysler Corp.

and Visitors

H. L. BROWNBACK (right) chairman of the International Reception Committee greets 1961 SAE President A. A. Kucher (left) in the International Lounge.

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Foreign

10. Birger Holmer, official delegate, Föreningen För Skeppsbyggnadskonst (Sweden); J. A. Poggio, official delegate, Sociedad de Técnicos de Automocion (Spain); Dr.-Ing. Wifredo P. Ricart, honorary president, Sociedad de Técnicos de Automocion (Spain); Tadamassa Yoshiki, vice president general director, Society of Automotive Engineers of Japan.

11. SAE Past President William Littlewood; R. E. Johnson, Past SAE director; and Dr. A. M. Ballantyne, secretary, Royal Aeronautical Society (England).

12. L. L. Colbert (facing camera), president and Board chairman, Chrysler Corp.

13. Tadamassa Yoshiki, vice president general director, Society of Automotive Engineers of Japan; Henry Ford II, president, Ford Motor Co.; Eiji Toyoda, president, Society of Automotive Engineers of Japan.

14. Forrest McFarland, past SAE director, and Muir Frey, an SAE director.

15. Hiromichi Nakamura, Nissan Motor Co., Ltd., and Prof. Mineo Yamamoto, official delegates, Japan Society for Aeronautical and Space Sciences.

16. René Lucien, president-director general, and Aimé Fourgeaud, official delegate, Société des Ingénieurs de l'Automobile (France).

17. L. C. Kibbee, an SAE director, and William F. Sherman, Automobile Manufacturers Association.

18. K. F. Wendt, dean, University of Wisconsin, and G. J. Liddell, an SAE director.

19. Lt.-Col. J. R. C. Finch, British Embassy; and Herman Bosch, official delegate, Koninklijk Instituut Van Ingenieurs (Holland).

20. Dr.-Ing. Wilfredo P. Ricart, honorary president, Sociedad de Técnicos de Automocion (Spain), and Malcolm P. Ferguson, president, Bendix Aviation Corp.

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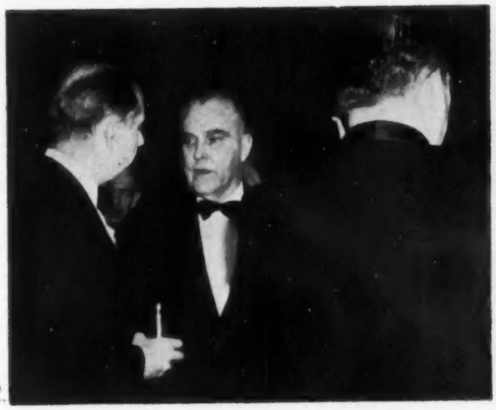
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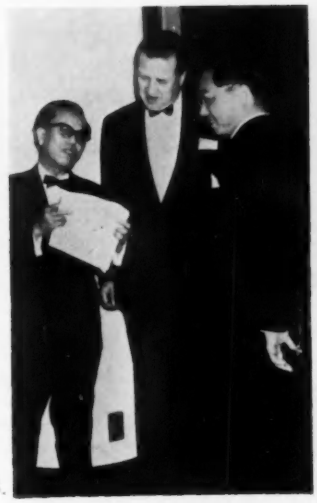
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Delegates and Visitors . . . continued


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at the

International Banquet . . .

. . . foreign delegates joined 13 SAE Past-Presidents and leading executives of the automotive and aerospace industries at the speakers table.

More than 1800 at the Banquet were seated in the unobstructed expanse of Cobo's vast banquet hall.

In his inaugural address, 1961 SAE President A. A. Kucher stressed . . .

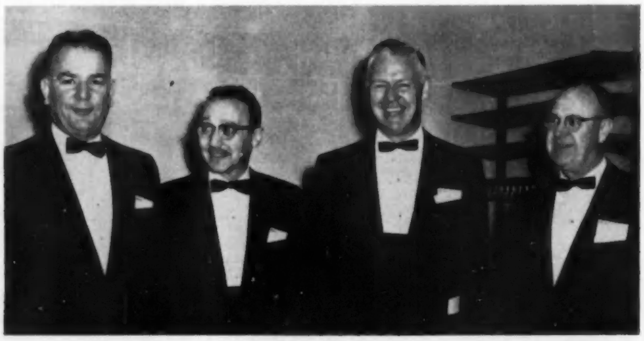
. . . the true values of an international congress. The knowledge exchanged, he said, is the most lasting element, but added: "This is true not only of the technical knowledge presented, but of the broader knowledge and understanding of each other that comes from the many personal contacts made."

Then he went on to say in part:

"Engineers in all parts of the world are being asked for more-than-revolutionary improvements in devices and products. They are being called upon to develop products of ever-increasing complexity . . . products which have the advantages of greater durability and greater reliability, yet are less costly to produce.

"The SAE has been a strong influence in turning advances in diverse fields of learning into engineering practice — and has kept our profession abreast of technological change. . . . The entire history of SAE has been shaped by such a pioneering spirit . . . and information exchange generated within the family of related scientific and engineering interests encompassed by SAE is precisely in tune with the needs of our present era."

DINNER COMMITTEE CHAIRMAN C. C. DYBVIG (second from right) is shown with members of the Special Reception Committee (from left) W. E. Burnett, M. J. Kittler, and B. W. Bogan, at a reception prior to the International Banquet.



JOHN F. GORDON (second from left), making the chief address at the Banquet, urged United States engineers and manufacturers to "reinforce our country's leadership in mass production . . . expose the faulty logic of false austerity by making freedom work . . . not by curtailing freedom, but by using it with all the energy . . . all the imagination and firmness of purpose we possess."

In the photograph (left to right) are: 1960 SAE President Harry E. Chesebrough, toastmaster at the banquet; General Motors President John F. Gordon, the speaker; 1961 SAE President A. A. Kucher, who made his inaugural address; and Max M. Roensch, Detroit Section chairman, who welcomed the dinner guests.

The two most formidable challenges facing automotive engineers today, said GM President John F. Gordon, are:

- **The challenge of foreign competition.**
- **The challenge of those who urge a new austerity . . . who urge that the American way of life is a sinful way.**

American engineers and producers have responded effectively to the challenge to design cars which would stem the tide of imported small cars. "But," he said, "we have no cause to be complacent. Imports still account for a sizable segment of our market; 400,000 to 500,000 units certainly are not to be sneezed at. . . . The American consumer has a mind of his own, and we can never be sure what his likes and dislikes are going to be tomorrow or the day after.

"We are continuing to respond successfully to the challenge of quality, too. It is high time for us to scotch forever the myth of European superiority in product quality. Most European manufacturers today use the same assembly-line techniques we do. . . . We must maintain a leadership in design, in quality, and in innovation."

Speaking of the second challenge, Gordon said:

"There has arisen in the United States of late a group of lay evangelists whose doctrine is — to put it bluntly — that the American way is a sinful way. They are exponents of a new austerity, a new Puritanism, a new Spartanism. They almost seem to suffer from a guilt complex. To these new hair-shirt philosophers, 'social' goods are intrinsically more important than 'personal' goods. They would have us believe that the United States is sacrificing social benefits for material indulgence; that our production of consumer goods — like automobiles — is using too much energy and too many resources that should be allocated to public goods like schools, hospitals and missiles. . . . They do not seem to understand, for example, that it is the production of consumer goods and services which make possible the tax revenues necessary to create the social goods. . . . In their book the customer is seldom right."

Questions we should ask these critics, Gordon said, include "Why is it sounder to have 'big brother' rather than the individual decide what his income should be?" . . . "Are decisions made by a bureaucracy better than those made by individuals?" . . . "Isn't a mistake made by a bureaucrat affecting thousands more disastrous than one made by an individual affecting only himself?" . . . "If the power of persausion of manufacturers is so irresistable, why do so many experience periodic difficulty in disposing of their products to consumers?"

"Most people, I believe, if given the opportunity, would rather prefer to live under a system in which citizens keep the most powerful controls in their own hands. . . ."

When 25,000 engineers came to SAE's 1961 Annual Meeting at Detroit's Cobo Hall . . .

- **The turnout was FOUR TIMES the attendance at any previous Annual or any other SAE meeting.**

- More SAE-member pins were sold at the Preprint desk — with only an 18 in. sign displaying them — than normally are sold in a three-month period. (The Society's entire stock was sold out . . . but it has already been replenished, in case somebody wants one right now.)

- **SAE Journal photographers used enough flash bulbs to fill two big suitcases . . . to get the nearly 300 pictures from which the 95 published here were selected.**

- **The Mayor of Detroit, The Honorable Louis C. Miriani, issued an official proclamation, complete with four "Whereases" and a concluding "Therefore" in which he proclaimed Jan. 9, 1961, as "Society of Automotive Engineers Day." In it, His Honor invited "all citizens and visitors of the greater Detroit area to join with me in recognizing the Society of Automotive Engineers as an organization dedicated to bringing the future marvels of transportation to practical reality."**

- More than 24,000 preprints of papers were sold . . . approximately one per attendee.

THIRTEEN SAE PAST PRESIDENTS were at the speakers table at the International Banquet to hear 1961 President A. A. Kucher deliver his inaugural address. Assembled just prior to the dinner for this picture, they are (left to right):
Standing: **Dale Roeder** (1951); **William Littlewood** (1954); **C. G. A. Rosen** (1955); **George A. Delaney** (1956); **W. Paul Eddy** (1957); **Leonard Raymond** (1959); **Harry E. Chesebrough** (1960); **A. A. Kucher** (1961).
Seated: **Jesse G. Vincent** (1920); **J. H. Hunt** (1927); **Ralph R. Teetor** (1936); **A. T. Colwell** (1941); **A. W. Herrington** (1942); **James C. Zeder** (1950).

HON. PAUL G. HOFFMAN, managing director of the United Nations' Special Fund (center), with Toastmaster J. N. Bauman (left), president, White Motor Co., and 1960 SAE President Harry E. Chesebrough (right), vice-president, Chrysler Corp. and general manager, Plymouth Division.

At the International Luncheon . . .

Hon. Paul G. Hoffman, managing director of the UN's Special Fund, characterized as the most pervasive revolution of all time "the revolt of no less than two-thirds of the world's people against the miserable conditions under which they have been living." . . .

. . . Engineers are largely responsible, Hoffman said, for the revolution of rising expectations which is taking place among two-thirds of the world's people. "These people," he said, "are determined no longer to accept poverty, illiteracy, chronic ill health, and despair as their way of life."

There are compelling political reasons and good sound business reasons — in addition to profound moral reasons — for assisting these underdeveloped countries, Hoffman stressed. "These countries are the great, new economic frontier," he said, emphasizing that not all of the billions so far spent have been spent effectively.

Careful study of natural resources, transportation and man-power potentials should precede the investment of United Nations' and other funds, he urged, saying:

"Each day brings new evidence of the need for much more knowledge of the physical resources of the underdeveloped countries." As a specific example of a rich, but little used resource, he cited the Mekong River, some 200 miles long, which rises in Tibet and flows through Laos, Cambodia, Viet-Nam, and Thailand. "This river," Hoffman said, "has a tremendous potential . . . but only recently have the surveys of this great resource — necessary as a prelude to sound investment — gotten under way."

Hoffman quoted a leading British atomic scientist, Sir Charles Snow, in urging that the time for action is here and now. Recently Snow said:

"Since the gap between the rich countries and the poor can be removed, it will be. If we are short-sighted, inept, incapable either of goodwill or enlightened self-interest, then it may be removed to the accompaniment of war and starvation. But removed it will be.

"The questions are . . . how and by whom?"

Hoffman concluded with the hope for momentum in aid to underdeveloped countries of such proportions that " by the end of this 20th century, poverty, illiteracy, and chronic ill health will have been wiped from the face of the earth."

SPECIAL SCROLLS were presented by the SAE to each of the foreign engineering Societies' delegates in attendance. Presentation of these Society-to-Society scrolls was made at the International Luncheon on Tuesday. Shown is Nils Nyström (left) receiving the scroll for Mekanik, Svenska Teknologföreningen from 1960 SAE President Harry E. Chesebrough. These scrolls read:

> **"To the officers and members of (*name of society*), cordial greetings from the officers of the Society of Automotive Engineers of the United States of America on the occasion of the SAE International Congress and Exposition of Automotive Engineering, Jan. 9–13, 1961 — Detroit, Michigan.**
>
> **"Tendering sincere appreciation for neighborly encouragement and helpful participation; with best wishes for further enhancement of friendly understanding through the sharing of engineering knowledge."**

EACH OFFICIAL DELEGATE of a foreign engineering society was presented with a scroll bearing his name and official status. Here is shown Robert Geffroy receiving his scroll from 1961 SAE President A. A. Kucher. The scrolls read:

> **"To (*delegate's name and title and name of society which he represents*) from the officers and members of the Society of Automotive Engineers with sincere appreciation for his distinguished participation in the SAE International Congress and Exposition of Automotive Engineering, Jan. 9–13, Detroit, Michigan."**

EACH PAPER AUTHOR FROM ABROAD received a scroll in appreciation of his participation at International Technical Sessions through the week. Shown at left is Dr. Walter Froede, who delivered a paper on "The NSU Wankel Rotating Combustion Engine," and Peter Altman, session chairman. The scrolls read:

> **"Cordial greetings to (*name of author*) from the officers and members of the Society of Automotive Engineers with sincere appreciation for his distinguished participation in the SAE International Congress and Exposition of Automotive Engineering, Jan. 9–13, 1961 — Detroit, Michigan."**

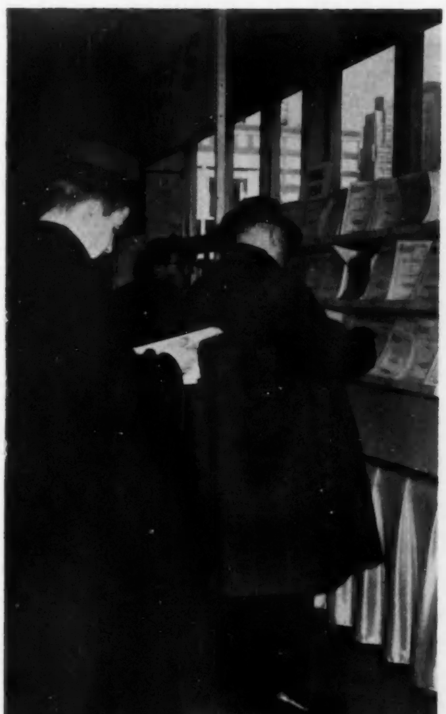
FOREIGN TECHNICAL SOCIETY PUBLICATIONS, supplied by the societies from which official delegates were invited to the Congress, were displayed in the Science Pavilion area . . . The display was of special interest to T. B. Rendel, (left) chairman of SAE's International Information Committee.

1960 BUCKENDALE LECTURER was V. J. Jandasek (right) who spoke on the "Design of the Single-Stage, Three-Element Torque Converter" at a well-attended Wednesday afternoon session. Following his presentation, Jandasek was presented with a certificate by P. H. Pretz who served as chairman of the L. Ray Buckendale Lecture Committee which chose Jandasek as the 1960 lecturer.

JOHN A. C. WARNER, now advisory consultant, was honored by SAE Past-Presidents at their annual dinner gathering. On behalf of the 22 living Past Presidents, he was presented with a watch and a certificate of appreciation for his 30 years as SAE Secretary and General Manager from 1930 to 1960. George A. Delaney (right), president in 1956, presented the watch; Leonard Raymond (left), president in 1959, the certificate.

SAE JOURNAL's ADVERTISING DEPARTMENT had booth Number 1839 in the Display area. . . . SAE Journal Advertising Manager E. D. Boyer (right) and Mendy Noble, manager, advertising development, are shown talking with James B. Ash, Borg Warner Corp.

SOCIETY SERVICES were listed in a display in the lounge area of the Science Pavilion. Inspecting the headquarters-prepared exhibit are: 1960 SAE President Harry E. Chesebrough (center); SAE Secretary & General Manager Joseph Gilbert (left); and A. A. Kucher, 1961 SAE president.



NEW PREPRINT SALES FACILITIES were set up to handle distribution of the record number of paper titles on sale. . . . A modified supermarket procedure was utilized.

1961 PUBLICATION COMMITTEE CHAIRMAN Leonard Raymond (right) and Dr.-Ing. Wifredo P. Ricart inspect the information booth set up to help explain SAE's expanded facilities for publication of full-length technical material through SAE General Publications. In Chairman Raymond's hand is a new booklet — "Know Your SAE Publications" — explaining the new facilities in detail. The booklet is available without charge to any SAE member upon request to SAE General Publications, Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y.

A. L. HAYNES (left), chairman of the Science Pavilion Committee, views the Science Pavilion through a 3rd floor vantage point in Cobo Hall with 1961 SAE President A. A. Kucher. Many companies and engineers cooperated in development of the Pavilion displays.

IN THE SCIENCE PAVILION were 20,000 sq ft of non-commercial exhibits which showed, among other things:

- **New ferrous materials and new ways to strengthen them;**
- **The widening spectrum of propulsion power sources, including fuel cells, the Stirling-cycle engine, and solar energy devices;**
- **New types of vehicles to give man added mobility over the earth's surface and through space;**
- **Application of SAE Standards in automotive equipment; . . . and many others.**

F. L. LA QUE (right) was responsible for the major contributions made to the Science Pavilion by the SAE Technical Board. Here he views one of the exhibits with 1961 Technical Board Chairman John G. Moxey, Jr. (center), and 1960 Technical Board Chairman A. A. Kucher.

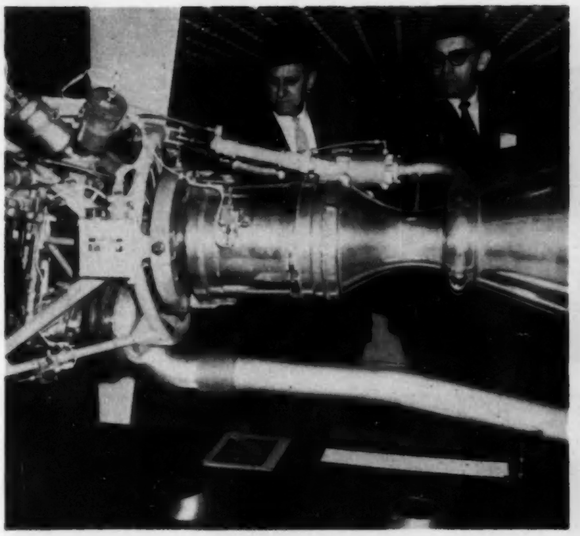
Instrument panel of space capsule

AROUND THE

In the

Thermoelectric energy conversion system and fuel cell

Saturn rocket engine

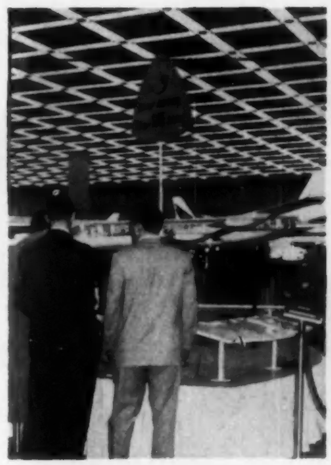


Agena rocket engine

Mercury capsule

INTERNATIONAL CONGRESS:

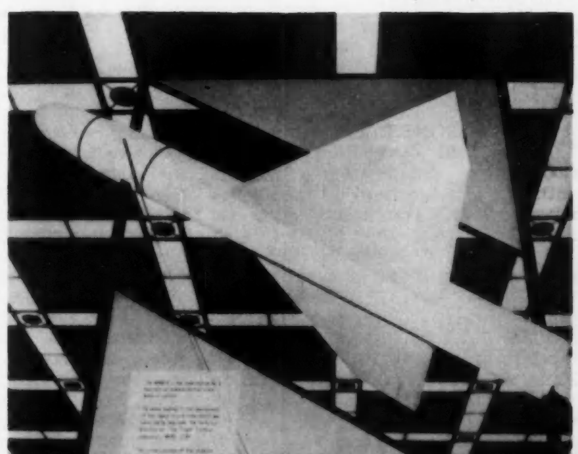
Science Pavilion



Jet transport aircraft

Seat design aids

Space capsule exterior



Amphibious cargo vehicle

1.

2.

3.

4.

GEN. ORVAL COOK, president, Aerospace Industries Association; Dr. A. A. Kucher, 1960 SAE Hechnical Board chairman, A. T. Colwell, chairman, SAE Finance Committee; and A. T. Burton, one of the luncheon speakers.

CEP Services to Industry

MEN RESPONSIBLE for industry's consistent recognition of SAE's Cooperative Engineering Program gathered at a luncheon on Monday to report on 1960 results and plans for 1961.

Speakers A. T. Burton, North American Aviation; F. L. LaQue, International Nickel; and G. E. Burks, Caterpillar Tractor Co., suggested new reasons for industry support and new potentials for stimulating that support. Finance Committee Chairman A. T. Colwell presided at the session which was attended by more than three dozen of the 50 CEP Vice-Chairmen and Group Leaders, who are responsible for increasing recognition of CEP by top automotive managements. As agents of the SAE Finance Committee, these men insure the flow of industry funds to SAE for the financial aid needed to keep CEP values to industry moving forward.

Present also at the luncheon as guests were Ralph H. Isbrandt, chairman of the Engineering Advisory Committee of the Automobile Manufacturers Association; Paul Ackerman, a member of the AMA-EAC; Gen. Orval Cook, president, Aerospace Industries Association; and 1961 Technical Board Chairman John Moxey, Jr.

Among those at the speakers' table were 1960 SAE President Harry Chesebrough and 1961 SAE President A. A. Kucher who was 1960 SAE Technical Board chairman.

This planning luncheon, held annually, is sponsored by the James M. Crawford Fund, created some years before his death by James M. Crawford, president of SAE in 1945 and chairman of the SAE Technical Board in 1946. The luncheon is one of the events helping toward the broad aims of the Fund as delineated by the late Past President to "enrich the satisfactions to individual SAE members resulting from their participation in SAE technical committee activity."

5.

6.

7.

Highlighted

1. Guest speaker Frank LaQue, who coordinated Technical Board participation in the Science Pavilion exhibit; Group Leader J. P. Charles; and John Moxey, Jr., 1961 Technical Board chairman.

2. Vice-Chairman Harold Nutt and Group Leader Gaylord Newton.

3. Luncheon Speaker G. E. Burks.

4. SAE Finance Committee Chairman A. T. Colwell and Paul Ackerman, who was a guest of honor.

5. Milton J. Kittler, an SAE director, and Ralph Isbrandt, 1959 Technical Board chairman.

6. Vice Chairmen C. J. Livingstone and R. Wayne Goodale.

7. Group Leaders V. J. Roper and W. G. Nostrand.

INCOMING TECHNICAL BOARD CHAIRMAN John G. Moxey, Jr., (left) receives a word of advice from 1960 Chairman A. A. Kucher prior to a luncheon where . . .

18 Engineers Received Certificates of Appreciation

PARTICIPANTS in the SAE Cooperative Engineering Program were honored at a special Technical Board luncheon where their achievements as members of SAE Technical Committees were cited by Dr. A. A. Kucher, 1960 Technical Board chairman. There to present Certificates of Appreciation to recipients was 1960 SAE President Harry E. Chesebrough.

Cited were achievements which have made possible the publication of SAE's new Aerospace Applied Thermodynamics Manual, progress on the proposed Shock and Vibration Manual, issuance of reports on central hydraulic fluids, industry acceptance of SAE Aeronautical Material Specifications as well as of important brake and lighting reports.

PROF. D. M. FINCH (left) is shown receiving a Certificate of Appreciation from 1960 SAE President Harry E. Chesebrough.

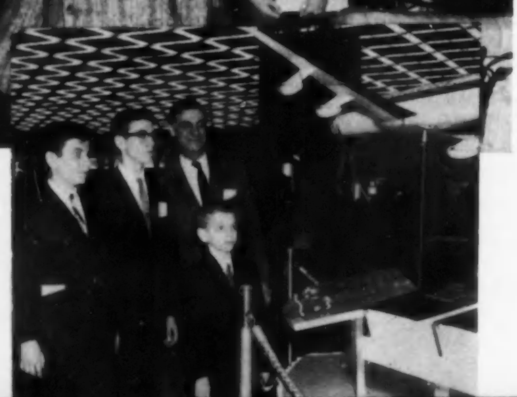
A. SCOTT CROSSFIELD (left), first pilot of the X-15, spoke on the X-15 Flight Test Program at the Detroit Section sponsored Father and Son session. **PHILIP H. PRETZ** presided as chairman.

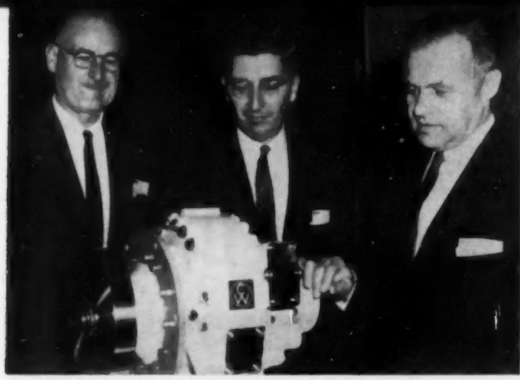
EUGENE J. MANGANIELLO (right), associate director, Lewis Research Center, NASA, spoke on Trends in Technology and How to Keep Up with Them. Chairman of the session was **KENNETH W. GORDON** (left), who heads the 1961 Student Activities Committee of the SAE Sections Board which sponsored this function.

600 Attended Student Programs

SPECIAL EVENING PROGRAMS were attended by a combined force of 600 student engineers . . . and fathers with sons, real or adopted for the occasion. Two programs were offered on Tuesday to stimulate the minds and imaginations of engineering school students as well as those of high school and junior high school students.

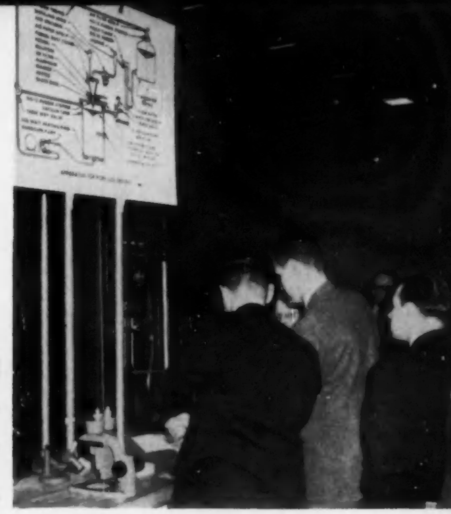
Prior to the sessions, both groups were invited to tour the Exposition and Science Pavilion as shown here.





Curtiss-Wright rotary combustion engine

Fuel filter test methods



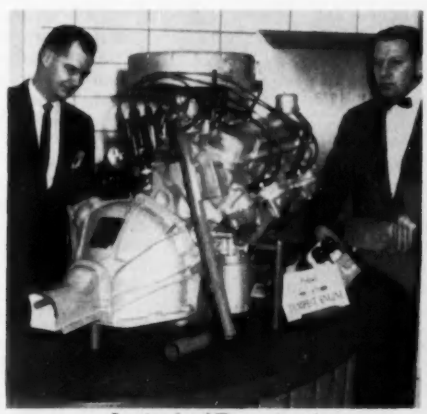
Apparatus for pore size testing

Rotary combustion engines

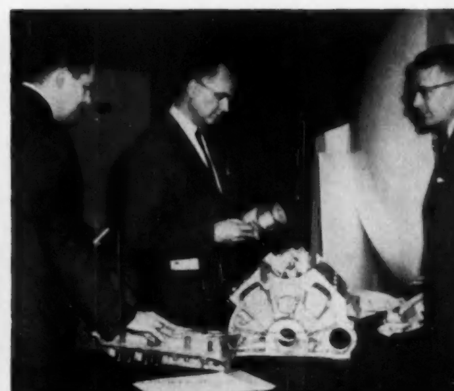
NSU-Wankel rotating combustion engine

Displayed at Technical Sessions were . . .

New engines for 1961 cars



Pontiac 4-cyl Tempest engine

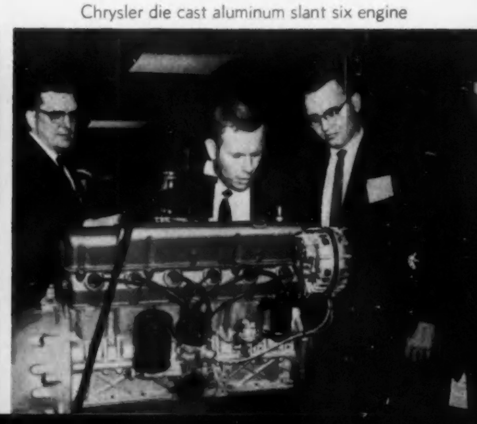


Buick V-8 aluminum engine block

Rambler die cast aluminum engine

Buick aluminum engine

Chrysler die cast aluminum slant six engine



Student Branch

Detroit Institute of Technology

General Motors Institute

SIX STUDENT BRANCH DISPLAYS were coordinated by William Coleman, vice chairman, Student Activities, Detroit Section. Coleman is also a member of the Student Activity Committee of the SAE Sections Board. Participating were Detroit Institute of Technology, General Motors Institute, Lawrence Institute of Technology, University of Detroit, University of Michigan, and Wayne State University.

SIX SAE STUDENT BRANCHES displayed engineering results of student efforts in the Science Pavilion at the SAE International Congress and Exhibition of Automotive Engineering at Cobo Hall, Jan. 9–13, 1961.

LAWRENCE INSTITUTE OF TECHNOLOGY showed the "Hansmobile," an aluminum automobile designed and constructed by LIT mechanical engineering students. Prof. Hans Ereneman, head of LIT's mechanical engineering department, directed the design and construction of the vehicle. . . . The LIT exhibit was prepared by LIT students, led and directed by SAE Student Branch Chairman Louis Smith and Branch Faculty Advisor Ken Snoblin. . . . Also shown was an exhibit demonstrating the strains present when a rifle is fired. This was under direction of Professor Levinson. . . . In addition, LIT showed a student-prepared explanation of a fluid flow experiment and several calculus problems were illustrated with models and computations.

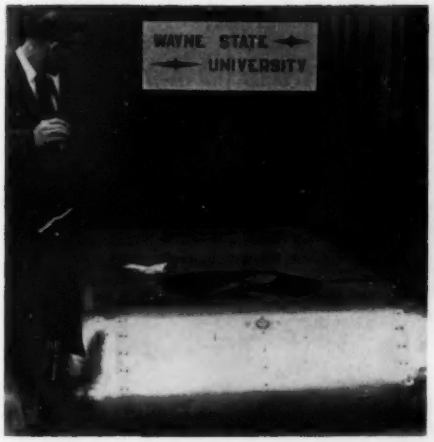
WAYNE STATE UNIVERSITY showed a plenum-chamber Ground Effect Vehicle, a continuing project of a group of SAE Enrolled Students: Carroll Grigsby, Ken Token, and Fred Hill. They did the job under the guidance of SAE Branch Faculty Advisor Milton G. Koenig, professor of mechanical engineering. . . . The vehicle construction consists of a plywood and aluminum frame, over which aluminum sheeting has been placed. Fiberglass is used for the compound curves of the corners.

UNIVERSITY OF DETROIT displayed a Ground Effect Machine, designed primarily to investigate the parameters and GE characteristics of an annular jet GEM having a low jet velocity and relatively high volume rate of flow. . . . Means were provided to vary the jet area, thereby changing the jet velocity (18 to 33 fps), and the volume rate of flow (6000 to 11,000 cfm). Gross weight was varied from 345 to 1150 lb. resulting in a maximum hovering height of 4.5 and 0.15 in. respectively. . . . The exhibit was developed by these SAE Enrolled Students: A. Kaupert, exhibit chairman; R. Korte, F. Jonke, D. Seiwert, and J. Gardner. Directing the student efforts were Faculty Advisors R. J. McHugh and A. C. Haman.

UNIVERSITY OF MICHIGAN exhibited a student-developed H_2–O_2 fuel cell, constructed to demonstrate the potential that the fuel cell has in replacing the gasoline engine in future automobiles. . . . Hydrogen and oxygen molecules are supplied to the cell from a storage tank. Once in the cell, the molecules are split into atoms with the aid of a catalyst — and then combine to form water. In the combining process, a flow of electrons occurs. This is used to operate the motor. . . . SAE Student Branch Chairman at University of Michigan is Dall Hedding; Faculty Advisor is W. H. Graves.

GENERALS MOTORS INSTITUTE Student Branch display featured projects showing various stages in the design of

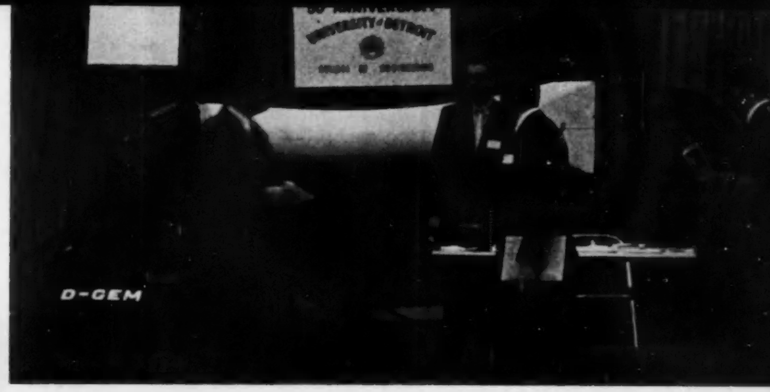
Exhibits



Wayne State University

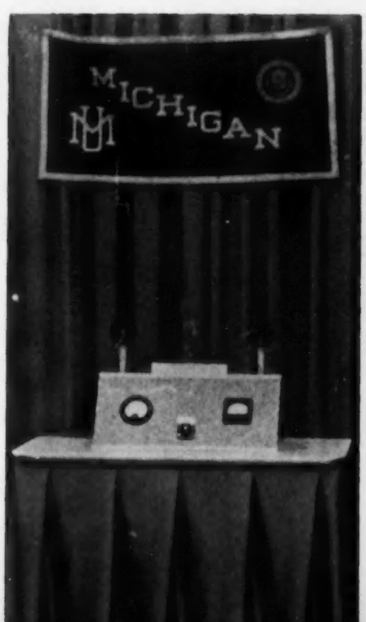
automobiles. A quarter scale layout and clay model are typical of the design projects. A structural section instrumented for static study and a body structure model for dynamic study are typical of projects developed for the testing laboratory. . . . SAE Student Branch Chairman at GM Institute is Edward Marshall; Faculty Advisor is Kenneth F. Lehman.

DETROIT INSTITUTE OF TECHNOLOGY displayed a Ground Effect Vehicle, designed especially for the SAE exhibit . . . and at the same site announced plans for further development and local exhibition of the unit. . . . This DIT-GEM was constructed in two stages. After many series of tests, the pilot model operated at a height of 2 in. off the ground. Then the exhibition model was constructed. The final vehicle incorporated new components and a streamlined cover. . . . Control of the vehicle is through four movable vanes located in the air stream. These vanes — which effect the vehicle's turning — also counteract torque effects from the power supply. Two linked vanes control the vehicle's forward and reverse movement. Remote control is through a 4-channel, frequency-modulated radio control unit. Relays on the receiver unit actuate the servos which, in turn, move the vanes. Student Branch Chairman Karl P. Straky was active in development of the exhibit. Faculty Advisor of the SAE Branch at DIT is R. N. Burns.



University of Detroit


Lawrence Institute of Technology



University of Michigan

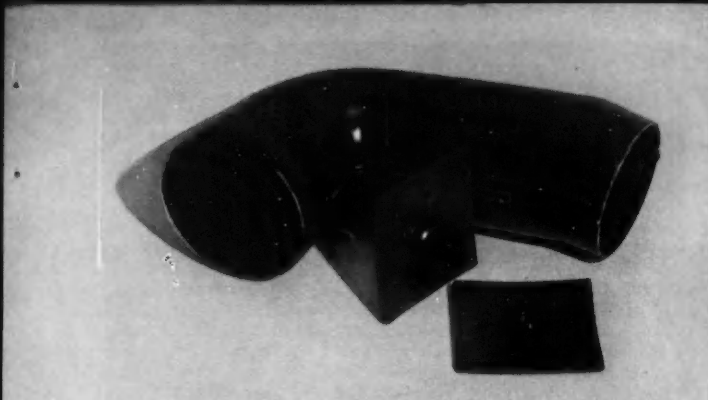
240 Engineers Tour Research and Assembly Facilities

TWO-HUNDRED and forty engineers, domestic and foreign, toured near-by research laboratories and assembly facilities during the International Congress. Arrangements made by Oliver K. Kelley, chairman of the Plant Tours Subcommittee, took three groups of 80 to . . .

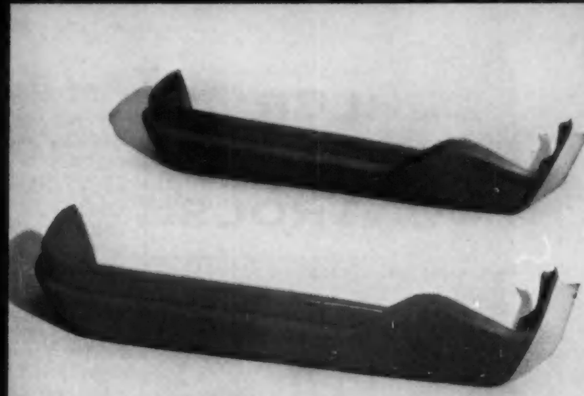
Plymouth Assembly Plant . . . Visitors saw a complete body assembly line from floor pan to fenders.

General Motors Technical Center . . . A chassis dynamometer bump and shake rig and GM free piston car were features of this tour.

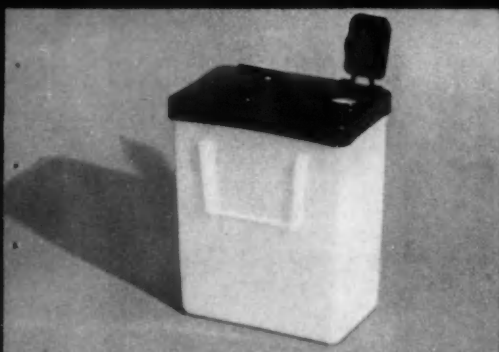
Ford Motor Co. . . . One group went through Ford's anechoic chamber and metallurgical facilities.



Spring Silencers and Heater Duct—MARLEX silencers are durable, self-lubricating, and less costly. Duct is flexible, rot-proof, withstands tears and punctures.



Seat Side Shields—Cost less than painted steel . . . dent and scuff resistant, lighter, easily cleaned, and with "molded in" texture and color.



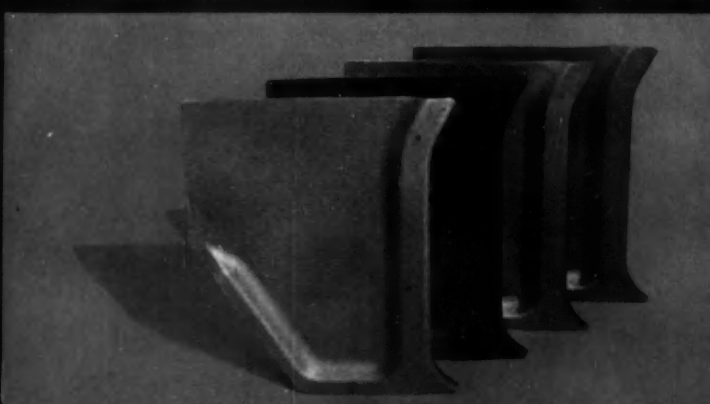
Windshield Washer Jar—MARLEX container and lid won't shatter or burst . . . are unaffected by freezing or under-the-hood temperatures.

The MARLEX* look on 1961 cars

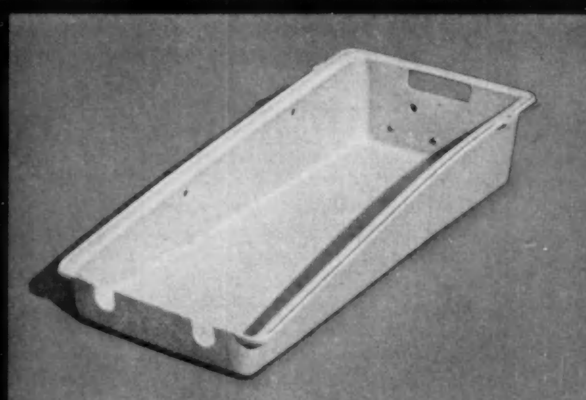
Shown here is a selection of current applications for MARLEX variously used by American Motors, Chrysler Corp., Ford, and GM. They offer new proof of the improved performance (at comparable or lower costs) provided by this versatile, high density plastic.

MARLEX items (like the original equipment applications shown here) are unaffected by extremes of temperature (—180°F to 250°F) and resistant to acids, alkalies, oil and grease. They are lightweight, tough, durable, non-allergenic, corrosion- and rot-proof . . . can be machined, welded, bolted, and printed upon. There are production advantages, too. Superior finished items can be quickly and economically produced from MARLEX high density resins by injection molding, extrusion, blow molding or thermoforming.

Technical and design data on MARLEX high density polyethylenes and ethylene copolymers, and their many uses, is available to you.



Side Cowl Panels—Colorful and textured MARLEX panels improve styling . . . will not scuff, dent, or tear . . . are color fast and easily cleaned.



Glove Compartment—Economical "quality up-grading" with MARLEX . . . new box is rugged, functional, and longer lasting.

*MARLEX is a trademark for Phillips family of olefin polymers.

For more information, see your plastic fabricator . . . or contact us.

PHILLIPS CHEMICAL COMPANY
Bartlesville, Oklahoma
A subsidiary of Phillips Petroleum Company

PHILLIPS 66 MARLEX PLASTICS

Rohr's record of achievement in precision metal

Part Quality . . .

Continued from page 87

bility characteristics and variations. Histograms and frequency curves are useful in studying these characteristics as well as in the study of useful life on dimensional problems.

In estimating the reliability of a given system for a given mission, knowledge of the current state of technological control is necessary. This state will be reflected by the consistency of the day-to-day frequency curve. However, what is really needed are techniques which detect slippage from a given state of technological control.

Serving on the panel which developed the information in this article, in addition to the panel secretary, were: chairman **D. R. Archibald**, Convair Astronautics; cochairman **E. P. Coleman**, University of California; **C. V. Armstrong**, Convair; **L. W. Ball**, Boeing; **W. E. Campbell**, Aerojet-General; **W. E. Cox**, Northrop; **E. J. Lancaster**, Air Force Ballistic Missile Center, Los Angeles; **R. F. Martin**, North American Aviation; **H. Schneiderman**, Aerojet-General; and **R. G. Paul**, Douglas Aircraft.

(This article is based on a report of one of 14 aerospace manufacturing forum panels. All 14 are available as a package as SP-333. See order blank on p. 6.)

New Requirements Spur Work on Filters

Based on paper by

F. R. GRUNER
and H. L. FORMAN

Purolator Products, Inc.

Material drawn from an

SAE Baltimore Section Paper

REINFORCED-paper, surface-type filter media and edge-type surface filters are undergoing steady improvement. And now, as operating temperatures of hydraulic systems rise to 300 F and higher, the reinforced papers in the surface filters must be replaced by the newer, stronger media made of nonwoven synthetic fibers.

Both paper and nonwoven synthetic fabrics are being worked with to reduce the number and size of the pores larger than the nominal pore size of the surface media. Here the objective is to give the surface media more closely controlled filtration properties and therefore better protection.

The higher operating temperatures of hydraulic systems are bringing into use more exotic hydraulic fluids because they possess superior nonflammable properties, greater lubricity, and higher viscosity indices. In some cases they affect filter element adhesives adversely, necessitating efforts to improve the cements to resistance in temperature ranges of −65 to +350 F.

Missile Requirements

Dutch twill, stainless steel mesh, surface filters have been developed to meet the missile industry's demand for a clean, strong, compact hydraulic filter through which no particle larger than 15 microns can pass. These filters are more costly than the reinforced paper or nonwoven synthetic fiber types, but their development has assisted in the improvement of the conventional filters.

Specifications for these new hydraulic filters are covered in MIL-F-8815. The tests are spelled out and the maximum-minimum limits imposed are so stringent as to force the adoption of manufacturing techniques foreign to the filter industry. New standards of cleanliness have brought about the use of special filter assembly clean rooms, equipped with filtered air and constructed of materials which minimize the accumulation of dust and airborne contaminants.

■ **To Order Paper No. S274 . . .** from which material for this article was drawn, see p. 6.

Safety Features Reduce Car Injuries

Based on paper by

R. H. FREDERICKS
Ford Motor Co.

SAFETY-DESIGN FEATURES in the modern automobile are greatly reducing the injury potential during all types of collisions. Data now available on actual traffic accidents involving cars equipped with these safety features show that:

1. The double-grip door latch has reduced the frequency of door openings during collisions by upwards to 50%.
2. The energy absorbing recessed hub steering wheel has reduced driver chest injury, particularly in the serious-to-fatal crushing-type category.
3. Padded instrument panels and sun visors have eliminated at least 30% of front seat passenger injuries and greatly reduced the seriousness of the injuries not prevented.
4. The seat belt has proved to be the most important single device for minimizing injuries. Matched-pair accident comparisons, in which the only difference was the wearing of a seat belt, have shown all degrees of injury are reduced 60% by the use of the seat belt. An additional study of identical accidents showed that moderate-to-

Continued on p. 128

Continued from page 126

fatal injuries were suffered five times less frequently when occupants were retained within the cars by seat belts and fatal injuries were increased eightfold when occupants were ejected.

Continuing studies are being made on seat belt designs and installation methods to develop optimum restraining devices. The automobile industry and seat belt manufacturers have cooperated through SAE in the preparation of a recommended practice for automotive seat belts. This recommended practice, which specifies minimum strength for the seat belt and components, is periodically reviewed and amended as experience is gained in the use and manufacture of seat belt equipment. The latest revision of the practice has been recently issued under the code designation SAE-GSA-4.

Data being compiled from the records of actual traffic accidents demonstrate the injury-reducing significance of the recently introduced safety-design features in the modern car. Such data also are contributing guidance for further refinement and development of specific injury-reducing designs, which will be progressively reflected in the cars of the future.

■ **To Order Paper No. S266 . . .** from which material for this article was drawn, see p. 6.

S-64A Skycrane Is Workhorse 'Copter

Based on paper by
W. W. LYSAK

Sikorsky Aircraft Division,
United Aircraft Corp.

THE Sikorsky S-64A Skycrane helicopter, now in the hardware stage, is designed to serve as a prime mover for conveyance or traction of external payloads of any reasonable size or shape. It will be powered by two Pratt & Whitney JFTD12 free-turbine engines, each rated at 4050 shp.

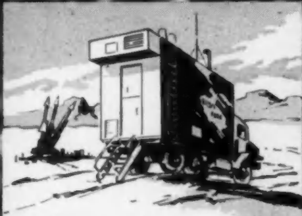
The payload can be coupled to the crane in three ways (1) by built-in winch, the hook portion lowered to engage and lift payloads, (2) by winch cable and hook to trail for towing purposes and, (3) by structural hardware fittings on underside of fuselage to accommodate pods or pallet loads.

Precision control of the crane is made possible by an aft-facing control position, giving the pilot clear vision of the load, the aircraft, and the terrain. Coupled with this is automatic stabilization equipment, which is ex-

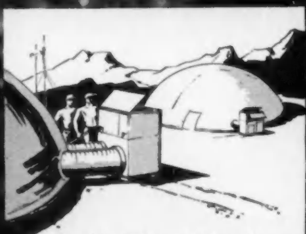
Continued on page 130

Compact air conditioning

for ground support use...

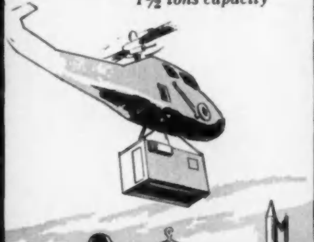


Trailer mounted refrigeration unit, 5 tons capacity



Inflatable shelter refrigeration unit, 7½ tons capacity (unit shown above)

Helicopter transportable hut refrigeration unit, 1½ tons capacity



AIRESEARCH 400 cycle ac Freon ground air conditioners are the most reliable and compact systems produced for ground cooling applications. They are easily transportable by helicopter or ground vehicle to any field location.

The compact, fully automatic unit shown at left, for example, measures 5x5x2 ft, weighs only 550 lb and provides 7½ to 10 tons of cooling on a 125°F day.

It also provides 90,000 Btu per hour heating.

The heart of the system is a simple centrifugal Freon compressor which has only *one* moving part.

A hermetically sealed unit, it operates virtually without vibration and is unaffected by either attitude or oil level.

Essentially the same AiResearch air conditioning system used in today's jet airliners, these lightweight units have more than 500,000 hours of proven dependability.

Built to withstand rough handling in the field and operate dependably under the most severe weather conditions, rugged air conditioners of this same basic design are available, or can be built to provide from fractional tonnage up to any capacity of ground cooling desired.

• A brochure describing AiResearch ground air conditioning systems may be obtained by writing to Environmental Controls Project, Los Angeles Division.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems and Components for: AIRCRAFT, MISSILE, SPACECRAFT, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

Continued from page 128

pected to give precision control of the crane in winds of 20–30 knots.

A nose-wheel type of alighting gear is used in preference to a tail wheel to allow unobstructed placement of loads and pods beneath the crane. Ground clearance is 112 in., sufficient to accommodate 8 × 8 ft cross-sectional cargo containers.

As a short-haul, heavy-lift vehicle, the S-64A will carry 8 tons of payload in both directions on a 40-nautical-mile radius against 20-knot headwinds. In an emergency it will carry 11 tons over a 20-nautical mile radius under a similar conditions but with some sacrifice of service life. Design makes provision for growth in normal payload capacity to 12 tons by modification of the transmission and rotor systems and by a reduction in the flight load factor from 2.5 to 2.1. The Skycrane can be ferried over a distance of 600 nautical miles, and this range can be extended to 800 miles by using a single-engine cruise technique.

Based on a design review of all components, the helicopter is expected to realize a ratio of useful load to gross weight of better than 50%.

■ **To Order Paper No. 266E . . .**
from which material for this article was drawn, see p. 6.

Small-Engine Batteries Have Some Limitations

Based on paper by

JOHN F. SCHAEFER

Battery Division, Globe-Union, Inc.

SUITABLE BATTERIES are already available for small-engine applications of all kinds. But the temperatures to be encountered in any projected application should influence strongly the particular type of battery selected for a particular engine.

Also, a voltage regulator system is probably necessary for satisfactory continuous-operation performance in the case of engine-mounted generator equipment. In intermittent service, however, as in normal power-mower usage, compromises can be made in the interest of economy. Service experiences show that — with limitation of current to relatively low values — battery life will continue satisfactory without a voltage regulator.

Assurance of satisfactory performance and life for batteries in small engines is enhanced, of course, by proper service use and judicious handling during idle periods.

■ **To Order Paper No. 276A . . .**
from which material for this article was drawn, see p. 6.

THE COLD LOGIC OF AIR BRAKE BUYING. A cold, logical bird, the owl. He plans his moves shrewdly—and is almost always successful in getting what he's after. Cold logic applies to air brake buying, too. Shrewd analysis of air brake devices and systems reveals a real difference between makes . . . in quality, performance and reliability. That's why it's important to consider the reputation and the record of all brands before you buy. When you do, you'll find Bendix-Westinghouse Air Brakes are the logical choice. Reason: Since 1923, we've manufactured to a quality and performance standard—not just to a price. This policy is your assurance you will continue to get most-value-per-dollar by specifying Bendix-Westinghouse Air Brakes—the product and name you can trust.

SPECIFY COMPLETE AIR BRAKE SYSTEMS BY Bendix-Westinghouse

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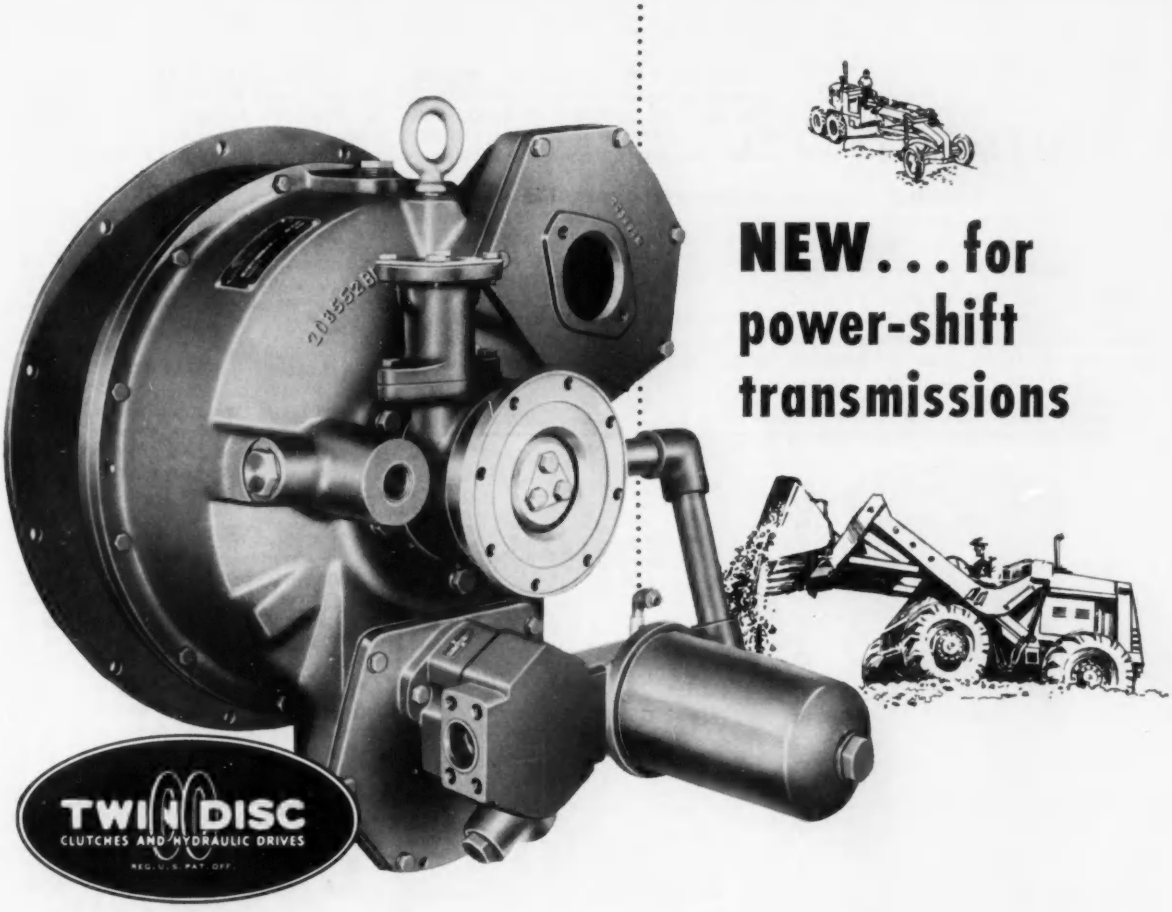


SUMPLESS Single-Stage Torque Converters with power take-off drives

From the world's largest manufacturer of industrial torque converters comes a new line of sumpless units . . . torque converters designed *specifically* for use in front-end loaders, tractors, motor graders and other vehicles with power-shift transmissions. One of these Twin Disc converters will make an ideal drive-line partner for the power-shift box on your drawing board.

Sumpless Twin Disc Torque Converters are single-stage units furnished in three different input torque capacity sizes: 1300 Series, 350 lb-ft; 1500 Series Standard-Duty, 450 lb-ft; and 1500 Series Heavy-Duty, 650 lb-ft.

All models have a PTO point normally used as a power implement pump drive. A second PTO point is furnished on the 1300 Series only. This is a lower capacity drive likely to be used for a steering pump on vehicles with power steering.

A pump for circulating the converter fluid through a cooler is standard equipment. On the 1500 Series units an optional duplex pump can be furnished. One side acts as the converter circulating pump while the other side provides a pressure head for actuating hydraulic clutches, cooling clutch plates and lubricating bearings in the power-shift transmission. Both pumps are furnished in a choice of two capacity sizes depending on cooling requirements. Where sumpless torque converters are used, the plumbing must be integrated into the transmission system, or an independently mounted sump supplied by the equipment manufacturer.

Bulletin 510 gives details and specifications on the complete line of Twin Disc Single-Stage Torque Converters. Write for your copy today. Twin Disc Clutch Company, Racine, Wisconsin; Hydraulic Division: Rockford, Illinois.

TWIN DISC
Torque Converters

SAE Members

Continued from page 97

ROSS E. NIELSEN has been named assistant manager of Champion Spark Plug Co.'s automotive technical services department. Nielsen was formerly manager of field engineering for the Chexall Corp.

WILLIAM M. KELLY has been appointed manager of government sales for the Axle Division of Eaton Mfg. Co. Formerly he was Detroit district sales manager for the Axle Division.

WILLIAM J. BIRD has been named director of fleet sales for Chrysler Corp. He was formerly assistant general manager, Dodge Car & Truck Division, Chrysler Corp.

MAX H. SCHACHNER has been appointed executive engineer for Keco Industries, Inc. Formerly he was manager, Cold-mobile Division, Union Asbestos & Rubber Co.

DONALD E. MASTIN is on an educational leave of absence from Rochester Products, Division General Motors Corp., doing graduate work in mechanical engineering at Tulane University.

JOHN L. S. SNEAD, Jr., (M'38) heads Chicago Express, Inc., with headquarters in Kearney, N. J. Snead, who is a past SAE Director, was formerly president of Consolidated Freightways, Inc.

WILLIAM F. MARTIN, formerly director of manufacturing services, Borg-Warner Corp., has been appointed vice-president and assistant general manager of Mechanics Universal Joint Division, Borg-Warner Corp.

Obituaries

RODERICK E. BAUGHN . . . (SAE Enrolled Student) . . . California State Polytechnic College . . . died November 3 . . . born 1938.

IRVING MACK . . . (M'49) . . . vice-president, Elastic Stop Nut Corp. . . . died September 5 . . . born 1906.

STANLEY MENTON . . . (M'29) . . . retired manager of manufacturing, General Motors Overseas Operations . . . died November 14 . . . born 1896.

CLARENCE A. PEIRCE . . . (M'18) . . . retired vice-president and director, Diamond T Motor Truck Co. . . . died December 12 . . . born 1886.

WARREN R. PETERSEN . . . (M'53) . . . powerplant staff engineer, Republic Aviation Corp. . . . died December 17 . . . born 1917 . . . he was an SAE Metropolitan Section Membership Committee Plant Representative and member of SAE Powerplant Controls Technical Committee.

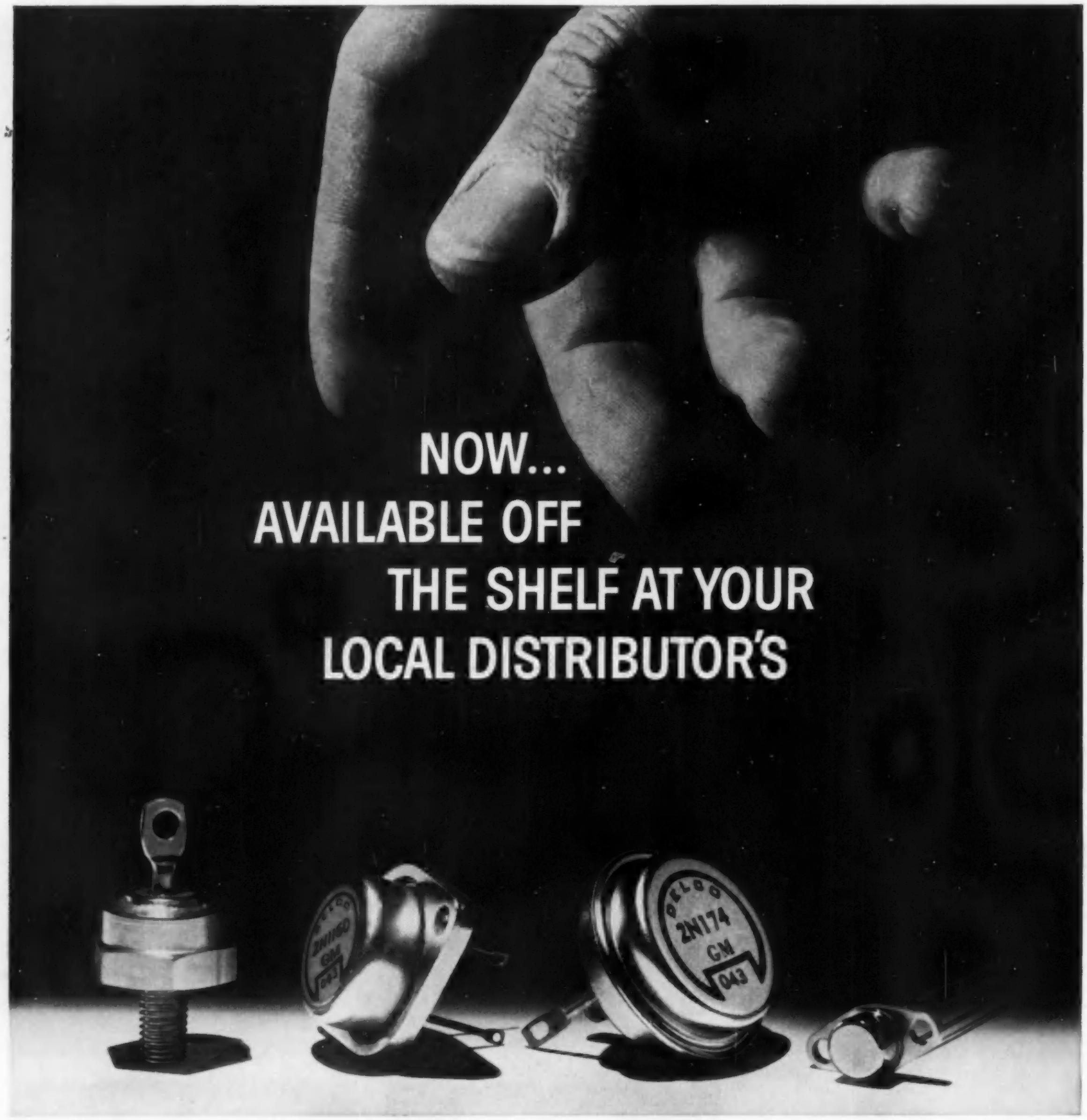
FRANK G. PREYER . . . (M'58) . . . designer-checker, Mack Trucks, Inc. . . . died November 2 . . . born 1907.

ALLEN W. ROMIG . . . ('47) . . . drawing checker, Missiles & Space Division, Lockheed Aircraft Corp. . . . died July 16 . . . born 1913.

ALLEN C. STALEY . . . (M'22) . . . retired . . . died December 2 . . . born 1885.

LAPE W. THORNE . . . (M'47) . . . owner, Lape W. Thorne . . . died August 8 . . . born 1893.

E. F. UPSHALL . . . M'43) . . . chief service engineer, Rolls-Royce of Canada, Ltd. . . . died October 19 . . . born 1909.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New Members Qualified

These applicants qualified for admission to the Society between December 22, 1960 and January 22, 1961. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Buffalo Section: William P. Neumeister (M), Elton C. Schwinger, Jr. (A), Paul Channing Stimson (J).

Chicago Section: John A. Boyd (M), Gordon E. Cole (M), Charles R. DeVane, Jr. (M), Jerrold A. Isaacson (M), James S. Jackson (M), Alan Joseph Peterson (J).

Cincinnati Section: Jerry W. Bartling (M), Thomas J. McGucken (A).

Cleveland Section: Edmund William Greenwald (J), Samuel Adam Kuzoff (J), John R. Perkins (A), Richard R. Reimer (M), John J. Rodgers (J).

Colorado Group: Hansford Barbour Anderson (A), Richard F. Frenzel (A).

Dayton Section: Merle Julius Athmer (J).

Detroit Section: Frederick W. Bloom (M), Harry J. Brown (A), Charles S. Brasch (M), Frederick W. Chesna (J), Stanley E. Chocholek (J), Carl H. Clendening (A), John R. Elwell (M), Earl Richard Fiene (A), James F. Gage (M), Dan Griffin, Jr. (J), Michael Murray Hentgen (J), Max J. Irland (M), James R. Kuehnel (A), George Fraser Luckett (M), Tage Madsen (M), Harry Charles Moore (M), Gilbert R. Richards (A), William M. Spaller (J), E. Stephen Tokarchuk (J), Jonas Valukonis (M).

Fort Wayne Section: Arthur B. Bok (M), Vernon A. Johnson (J).

Indiana Section: Carlton Lee Duncan (J), Mark Edwin Fisher (M), Leonard D. Gardner (A), Floyd Arnold Kunce (J), Floyd L. Smith (A).

Kansas City Section: Theodore F. Barrett (M).

Metropolitan Section: Juan Enrique Cruz (J), Brett P. deDube (M), John A. Farris (J), David Jacobs (J), Robert C. Wade, Jr. (A).

Mid-Continent Section: Billey Paul Hensley (J), Allyn G. Warkentin (J).

Mid-Michigan Section: Mark Lane Herfurth (J), Ronald Lloyd Kyle (J), Roman J. Martin (A), Fred O. Schulte (J), Robert Carl Stempel (J).

Milwaukee Section: William James Downie (M), Richard Phillip Emmerich (J), George W. Gross (J), Ronald L. Luebke (M).

Montreal Section: Joseph Camille Rivet (A), Richard Frederick Robertson (J).

New England Section: Maurice Gertel (M).

Northern California Section: David Leslie Blomquist (J), Roderick Edward Hussey (A), James Russell Rogers (J).

Northwest Section: Laird W. McKee (J).

Ontario Section: Harry A. J. Atkins, Jr. (J), Donald Charles Buckley (M), Lorne Clifford Clarke (J).

Philadelphia Section: William Robert Kane (A), Robert A. Moon (M), Donald LeRoy Eugene Terry (J), Earl Robert Walton, Jr. (A).

Rockford-Beloit Section: William J. Storey (J).

St. Louis Section: John Leonard Niebrzydoski (J).

Salt Lake City Group: James D. Calvin (A).

Continued on page 138

New Members Qualified

Continued from page 137

San Diego Section: Theodore Charles Tyce (M).

Southern California Section: Philip Mitchell Beck (J), Elliott David Brown (J), Robert Stephen Cannell (J), Allan Kanov (M), Carmine Anthony Pilichi (J), William Rust (J), Don Gilbert Schattschneider (A), Simon Tamny (M), Robert A. Wilson (J).

Southern New England Section: Don D. Cummins (J), Paul Rudolf Rey (M), Vincent J. Sansevero, Jr. (J), Frank S. Weldin (J).

Texas Section: James Clifton Blackmon (J).

Twin City Section: Clifford C. Bigley (A).

Washington Section: Bart Spano (M).

Western Michigan Section: Paul F. Bergmann, Jr. (A).

Outside Section Territory: Rene B. Eppi (A), Nicholas Tony Frangias (J), Raymond Filmore Gillen (M), Roger Howard Hansen (J), James Wm. Minamyer (J).

Foreign: William Douglas MacTaggart Black (M), Australia; Eric H. Bowers (M), England; Manuel Julian Irigoyen (M), Argentina; Tetsujiro Ozono (M), Japan.

Applications Received

The applications for membership received between December 22, 1960 and January 22, 1961 are listed below.

Atlanta Section: B. Leo Wilson

Central Illinois Section: Donald Robert Buerschinger, James Arnet Hooker, Lowell Ernest Johnson, James Phillip King, Lyle Robert Madson

Chicago Section: Donald W. Feidt, Donald George Hallahan, Paul Hanebuth, Myron Reynold Holmgren, Jr., Ashley Kennedy III, Richard D. Schwartz, Frank William Stillo

Cincinnati Section: Steve John Steinoff, Carl Walter Weiland

Cleveland Section: Albert Carl Benning, Eugene Foster Dornbrook, Hans Joachim Heine, Richard G. Priest

Dayton Section: John Henry Apel, Ernst Hermann Ruf, Leo S. Sullivan, Jr.

Detroit Section: William Frank Barr, Edward Francis Blackburne, Alan Copping Booth, Emmett Vincent Brogan, Charles William Bugbee, Richard Lyons Campbell, Russell M. Cooper, Joseph Cugliari, William Laurence Cundy, Peter S. Davis, W. E. Davis, Robert Gene Edwards, Jerome D. Freedman, Fred A. Gluckson, Paul Edward Haldeman, David Peter Hass, W. Clifford Henderson, Ananthakrishna Anantha narayanan, Donald J. Henry, Gilbert J. Hensien, Leroy J. Herbon, George Rusling Humphreys, Richard Thomas Jensen, Ellis R. Lovell, William A. Lunsford, Frederick Henry McKaig, Edward Rowland McKenna, Gerald W. Messenger, William Louis Nagy, Robert Evans Newman, Edwin Wallace Norman, Richard John Pattison, Joe Albert Polisano, Hermann Bernhard Ramcke, Leo Salakin, Irvin L. Slane, Raymond Paul Smock, James I. Stalker, James A. Stumph, William Trampus

Fort Wayne Section: Steven D. Huntsman, Robert LaVerne Tordoff

Hawaii Section: Lee B. Porter

Indiana Section: Albert C. Booth, John K. Smith

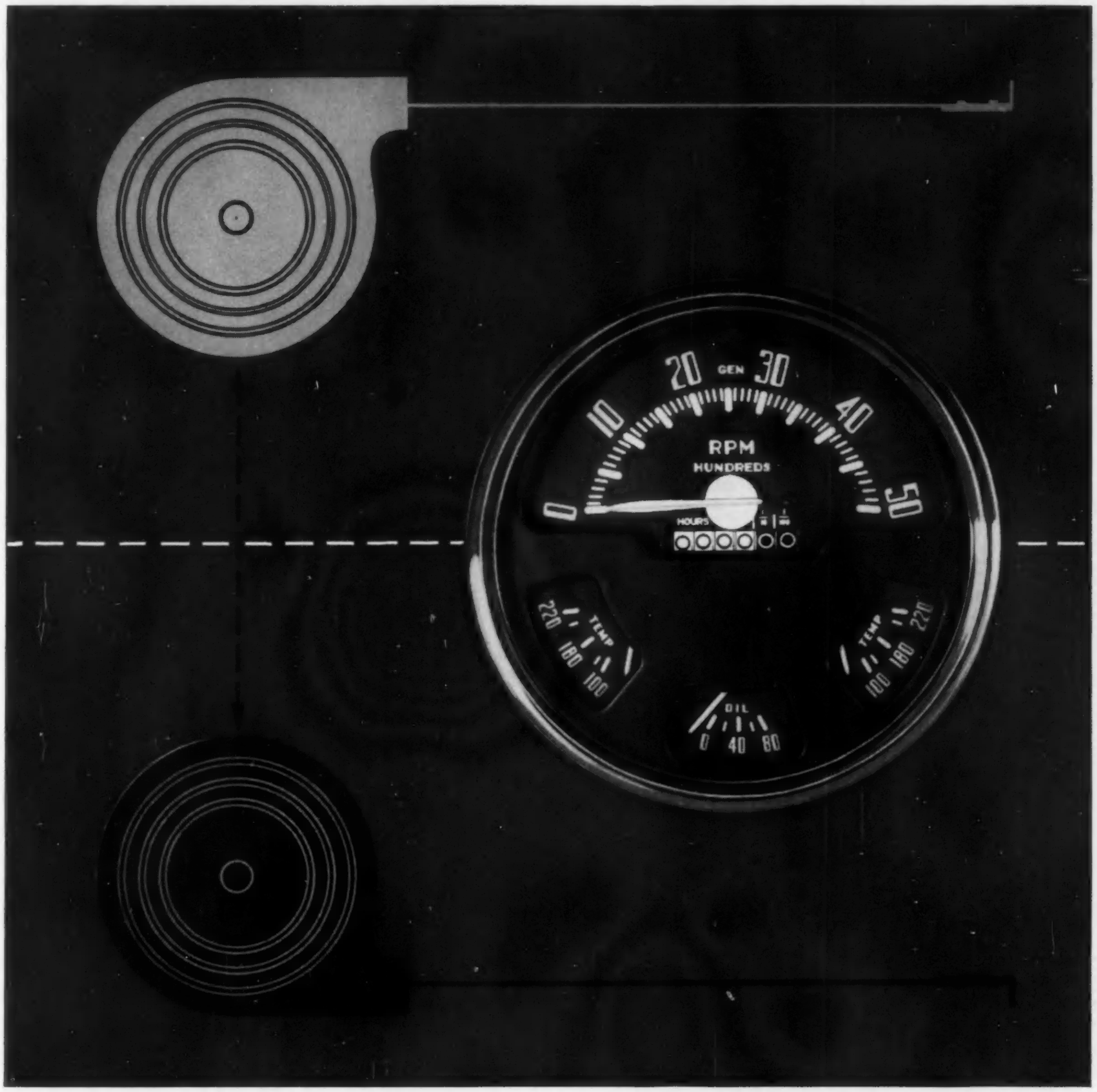
Kansas City Section: Don Frederick Sole

Metropolitan Section: Eitaro Kurihara, Angus McPherson Laidlaw, Lawrence Martin Mozzar, Justus P. Nesbitt, Halsey Paul Quinn, James Joseph Rawling, Donald George Terek, James R. A. Walker

Mid-Michigan Section: Gian Luigi

Continued on page 141

YOU CAN'T BEAT AC FOR PRODUCT KNOWLEDGE



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Thirty-five years of instrumentation experience has led to many important AC achievements: AC has designed and developed over 2000 instrument clusters . . . AC instrument applications range from small inboard boats to heavy-duty off-the-road construction equipment . . . AC has 15 specially trained engineers working exclusively on instrument design and development . . . AC instrument engineers spend over 3000 hours yearly working with customers in their own plants. AC instruments are performance-proved in continuous tests. AC has the latest equipment for developing customer instrument samples. For expert instrumentation advice and help, call the nearest AC office below. You'll get fast ACtion at AC!

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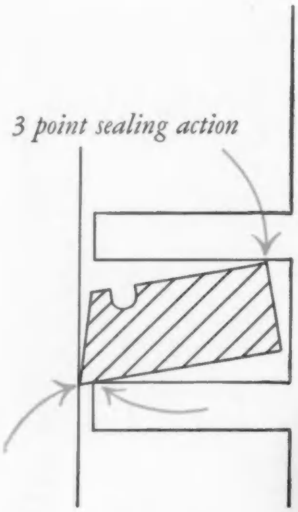
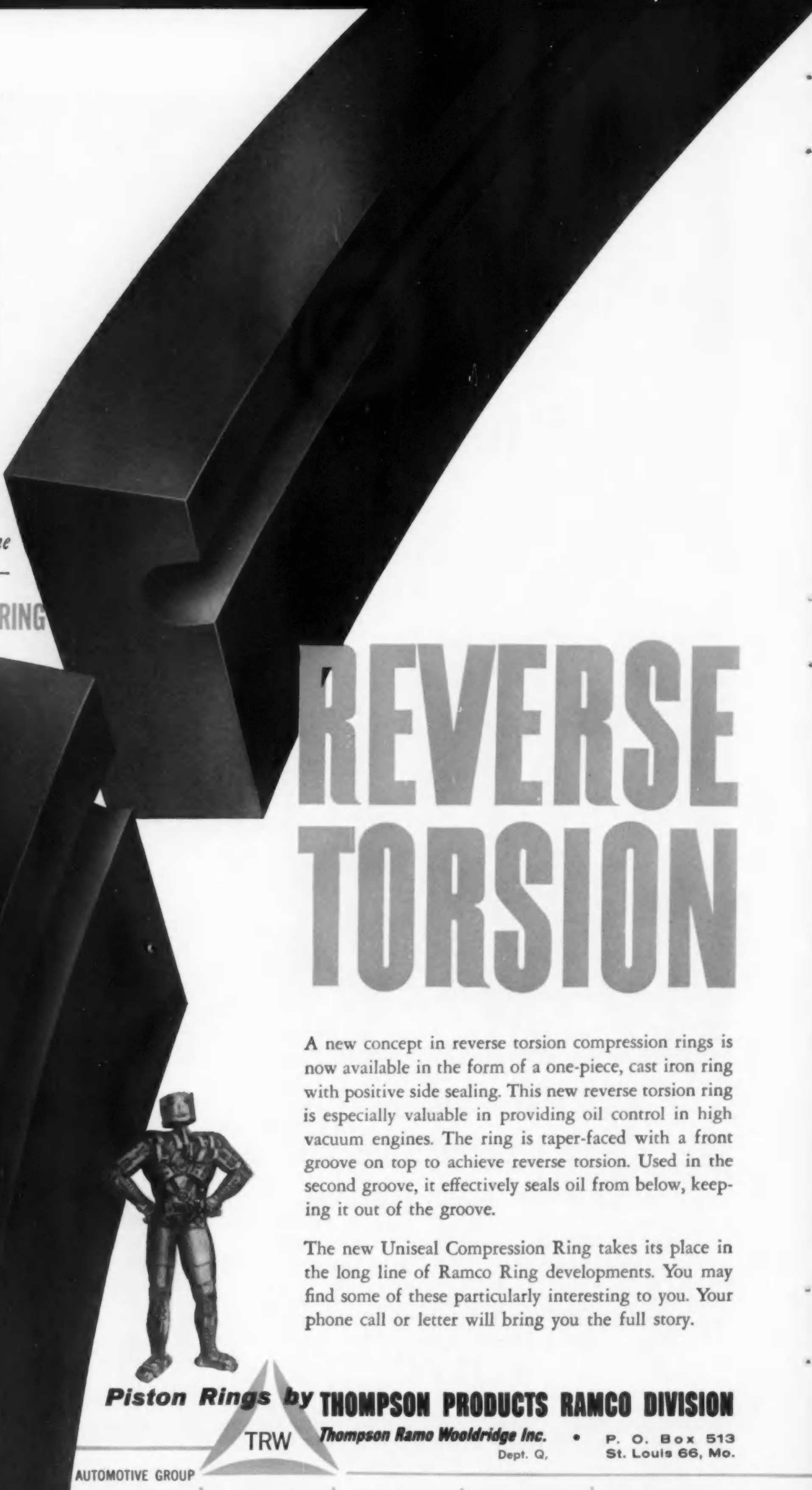


new, for high vacuum engine compression and oil control—

UNISEAL COMPRESSION RING



REVERSE TORSION

A new concept in reverse torsion compression rings is now available in the form of a one-piece, cast iron ring with positive side sealing. This new reverse torsion ring is especially valuable in providing oil control in high vacuum engines. The ring is taper-faced with a front groove on top to achieve reverse torsion. Used in the second groove, it effectively seals oil from below, keeping it out of the groove.

The new Uniseal Compression Ring takes its place in the long line of Ramco Ring developments. You may find some of these particularly interesting to you. Your phone call or letter will bring you the full story.

Piston Rings by **THOMPSON PRODUCTS RAMCO DIVISION**

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AUTOMOTIVE GROUP

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Applications Received

Continued from page 138

Barisone, Richard Allen Miller, Leonardo Monacelli, Donald Earl Mueller, Gerald Edwin Roy, Robert J. Ruggles, Donald K. Steiner

Milwaukee Section: Eugene Walter Cismoski, William Lee Hammer, Robert Harold Jensen, Timothy M. Seth, Richard W. Swanborg

New England Section: John A. Chafey

Northern California Section: Donald D. Collins, Emiel T. Nielsen, Jr., Wayne E. Thompson

Ontario Section: Michael John Kirwin

Oregon Section: Earl Richard Buck

Philadelphia Section: Olaf K. Szamody, Willard Thomas Williams

Rockford-Beloit Section: John C. Morton, M. J. Vause

St. Louis Section: Walter Erwin Caesar, Otto Joseph Muehlbauer, Leonard Arnold Stein

San Diego Section: Robert L. Bedore, August S. Lermer, Charles William Newhall

Southern California Section: James Bernis Bristol, Newel Whitney Johnson, Joseph E. Leach, Jr., Evald Erik Lindgren, Ted Maier, Jr., Thomas Cuthbert Waller III

Syracuse Section: John Gustin Lanning, Robert Frederick Uhl

Texas Gulf Coast Section: Raymond F. Adams, R. Sterling Barnett, O. J. Cole, W. W. Litchult, William Conner Woerner

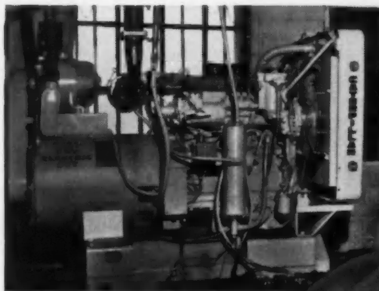
Virginia Section: Jan D. Hanrath

Washington Section: Donald Bruce Talmage

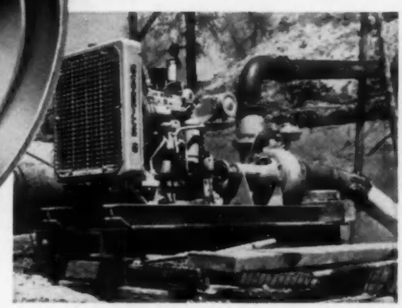
Western Michigan Section: John J. Cummings, James A. Dykema, Konrad Hugh Marcus

Outside Section Territory: Joseph Fernand Blais, Stephen Edgar Crane, Daniel Voyied Johnson, Raymond S. Poppe, Jerry O. Pregenzer, James Francis Sweet

Foreign: Thirumalaikolundupuram Ananthakrishna Anantha narayonon, India; Pierre Etienne Bessiere, France; Alberto Cory C., Mexico; Oma Manilal Fernando, Ceylon; Ryoichi Nakagawa, Japan; Maurice Subit, France; Jiro Tanaka, Japan; Mineo Yamamoto, Japan; Yves Jean van Delft, Belgium; Jambunathan Venkataraman, India



Caterpillar 130 hp D320 turbocharged industrial engine: with generator set supplying all power to 5,000 watt radio station . . . in high speed marine application . . . driving air compressor for mine and quarry operation . . . driving water pump for gravel pit operation



AiResearch T-6 turbocharger (weighs 24 lb, 7¾ in. diameter)

Economical turbocharging of Caterpillar's 130hp D320 engine

Economical turbocharging of Caterpillar's small, versatile D320 engine with AiResearch's T-6 turbocharger results in a highly efficient engine that is lower in original cost, more economical in operation and smaller in size than a naturally aspirated engine of the same horsepower.

The turbocharging of this economical power unit was developed jointly by AiResearch and the Caterpillar Engine Division. Integration of the turbocharger and engine is economical because of the turbocharger's simplified design and low cost. The turbocharger design incorporates a free vortex housing, eliminating the need for nozzle rings and providing higher turbine efficiencies.

AiResearch is a world leader in the development and manufacture of high performance, low cost turbochargers and turbocharger controls for internal combustion engines ranging from 50 to 700 hp.

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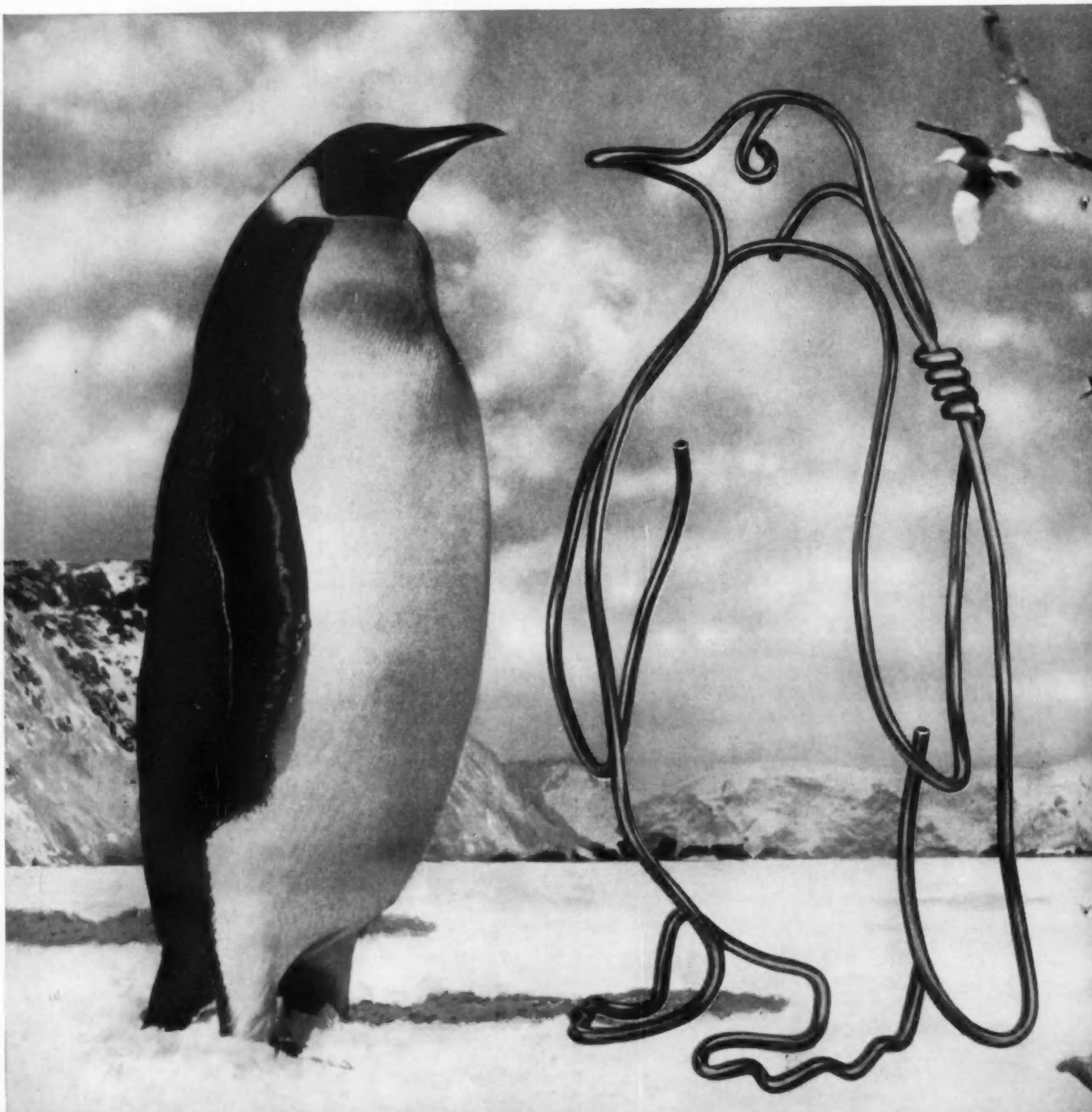
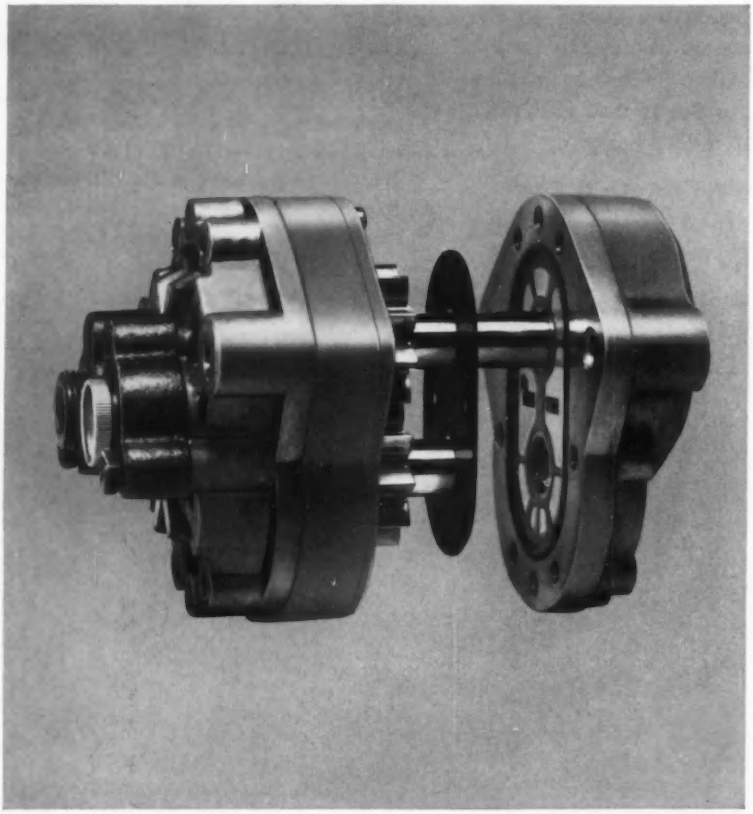
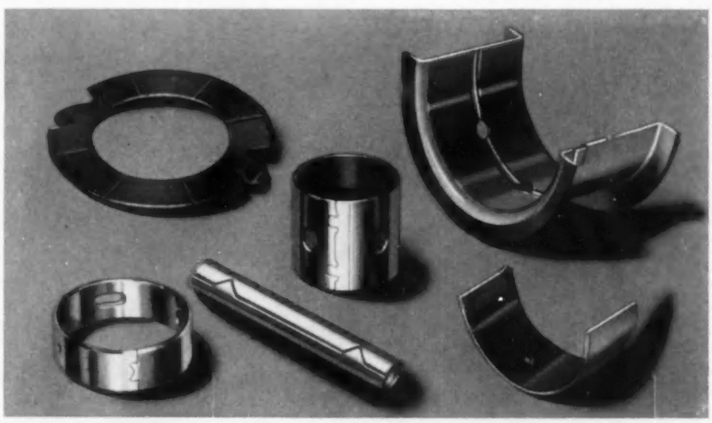


F-M WEAR PLATE "RIDES HERD" ON TURBULENT PRESSURE



IN CESSNA'S NEW HYDRAULIC PUMP LINE, F-M WEAR PLATE DIAPHRAGMS KEEP FLUIDS IN LINE to deliver pressures up to 2000 psi for aircraft, farm and construction equipment, many other hydraulic applications. These wear plate diaphragms maintain positive contact with gears to assure high, uniform pressure. To provide a bearing surface for this job, Federal-Mogul applies a high-density bronze to steel by a special sintering process. F-M high-density bronze prevents fluid absorption, and it affords good lubricity, needed because some hydraulic fluids are poor lubricants. To further prevent the escape of hydraulic fluid, these F-M diaphragms are manufactured for a snug, close-tolerance fit in the pump housing.



A DESIGN GUIDE provides valuable engineering data for designers on F-M thrust washers as well as wear plates. Also available is literature on sleeve bearings, bushings and spacers. For your copies, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11035 Shoemaker, Detroit 13, Michigan.

THE COMPLETE LINE of products from Federal-Mogul Division includes sleeve bearings, bushings, spacers, thrust washers, as well as wear plates. Through the years, F-M has amassed a wealth of knowledge and experience . . . from constant research, from solving bearing design problems for all kinds of products. Our engineers are ready to put this know-how to work and tailor bearing products to your requirements . . . with top performance assured.

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Eclipse Machine Division
Elmira, New York

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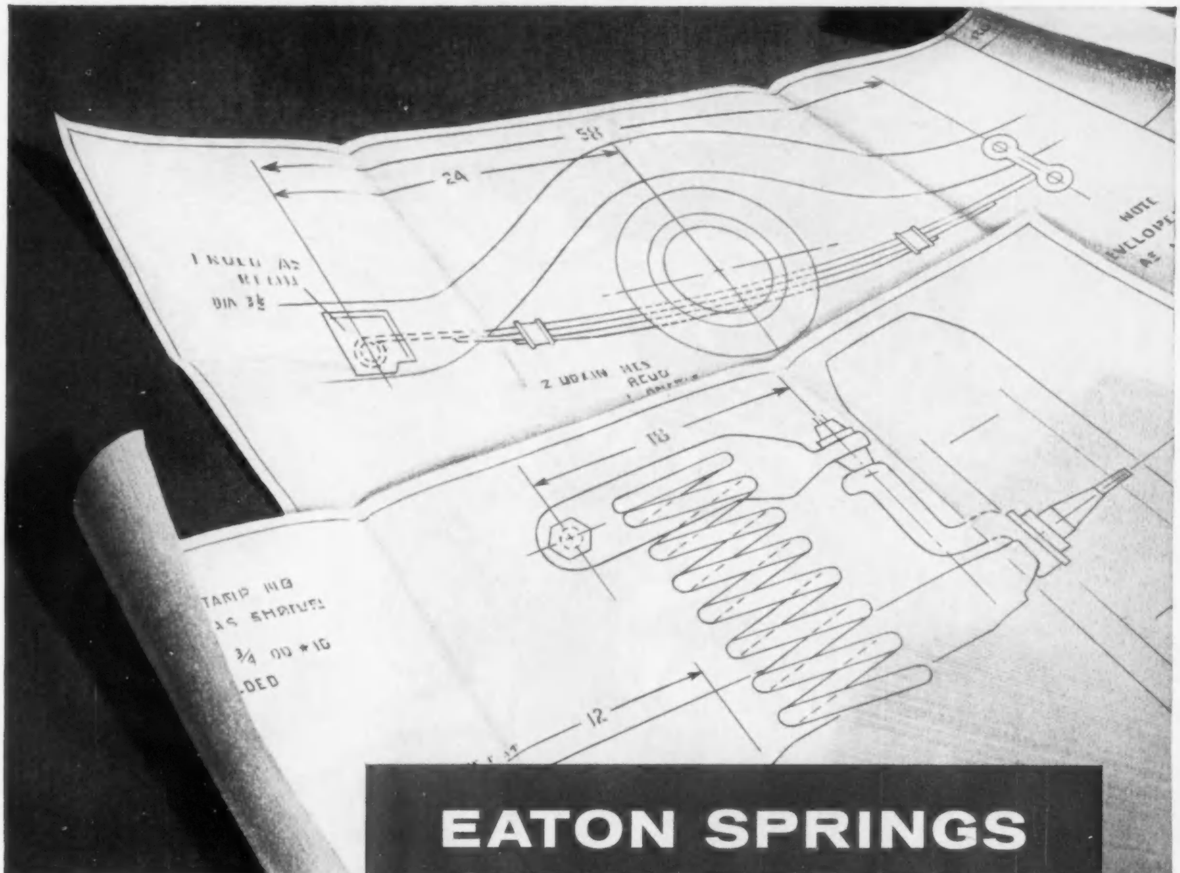
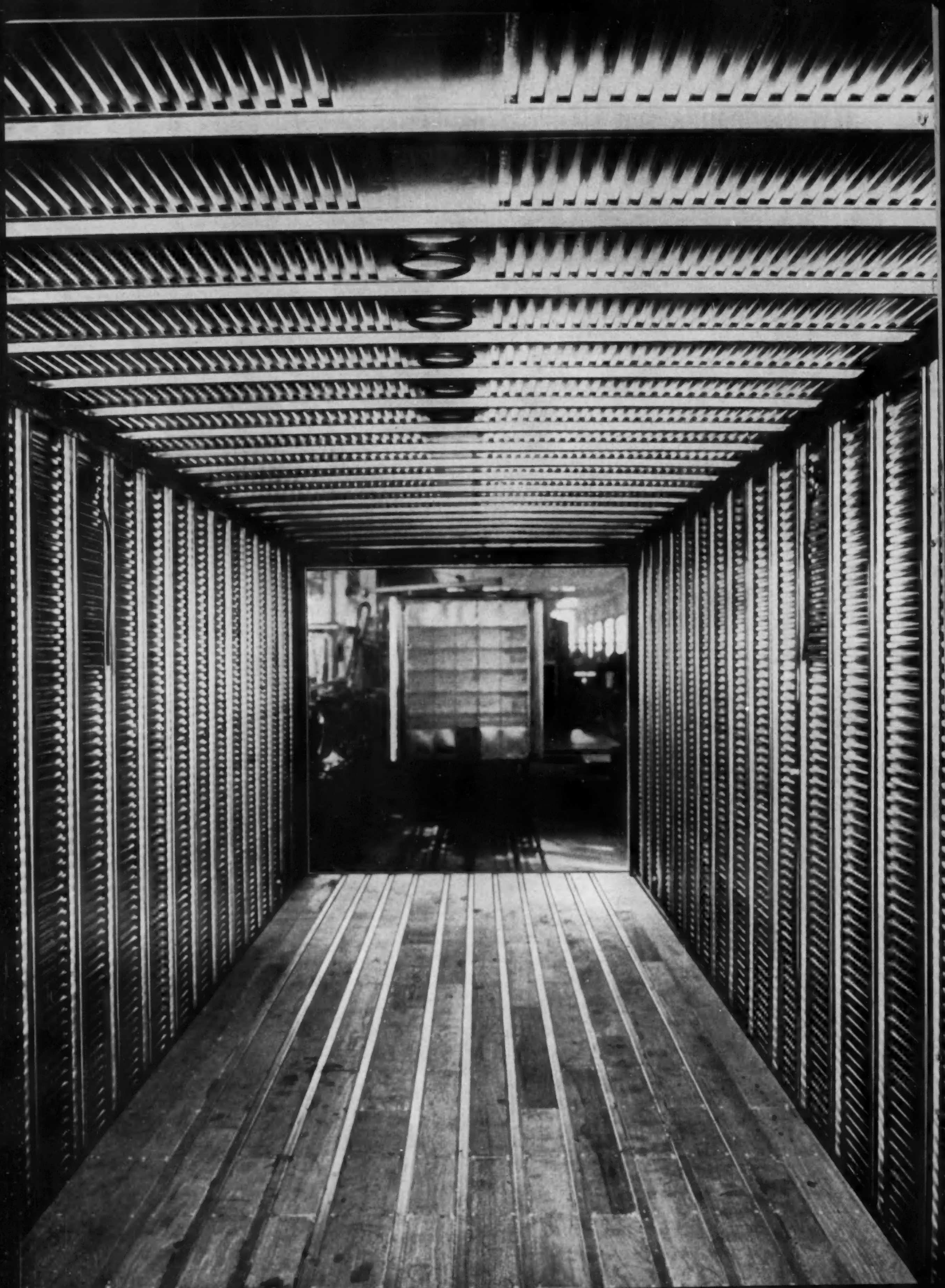
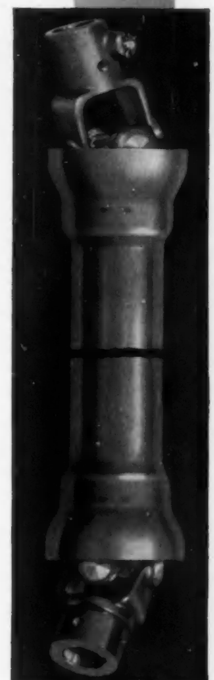




RELIABLE

Whether for close-coupled main drive lines or for exposed steering and adjustment drives, designers have learned to rely on MECHANICS. Where joints must run all day at high angles—where there are severe shock loads—where wide angles and long slip are common — and where dirt and/or moisture constantly are present—MECHANICS Roller Bearing UNIVERSAL JOINTS are used. Lubrication is so tightly sealed in that dirt and moisture cannot enter. Our engineers will be glad to show you how MECHANICS Roller Bearing UNIVERSAL JOINTS will help insure the reliable operation of your product.



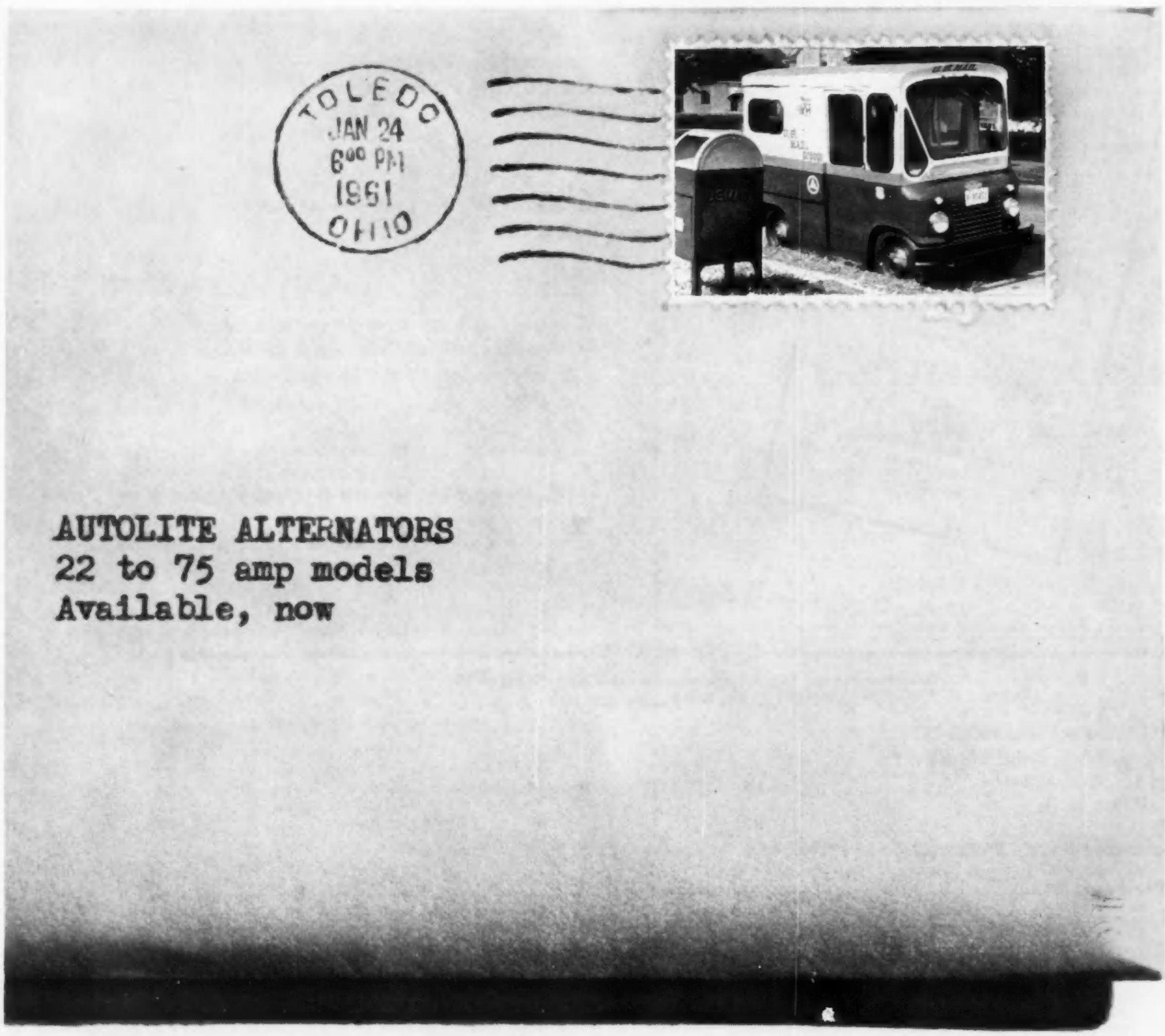
MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2022 Harrison Ave., Rockford, Ill.

MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS
For Tractors • Trucks and Farm Machines

Export Sales: Borg-Warner International
36 South Wabash Chicago 3, Illinois

This idler's an Autolite alternator. Standard equipment on Willys 'Jeep' Fleetvans now being supplied to the Post Office. Willys Motors, Inc. used it to solve the electrical problems of postal stop-and-go driving. Willys also found they were lighter, more compact, easier to install than conventional DC generators. Also found they cost less. Got a current generating problem? We can handle it. We have the first full line of automotive alternators in the business. Standard, Heavy, Extra Heavy Duty. Thoroughly tested. Ready for your specific application now. Every one packs more power per pound, more amps per inch at high speed or working at idle. Like to know more? Drop us a line: AUTOLITE ALTERNATORS, ELECTRICAL PRODUCTS DIVISION, TOLEDO 1, OHIO.

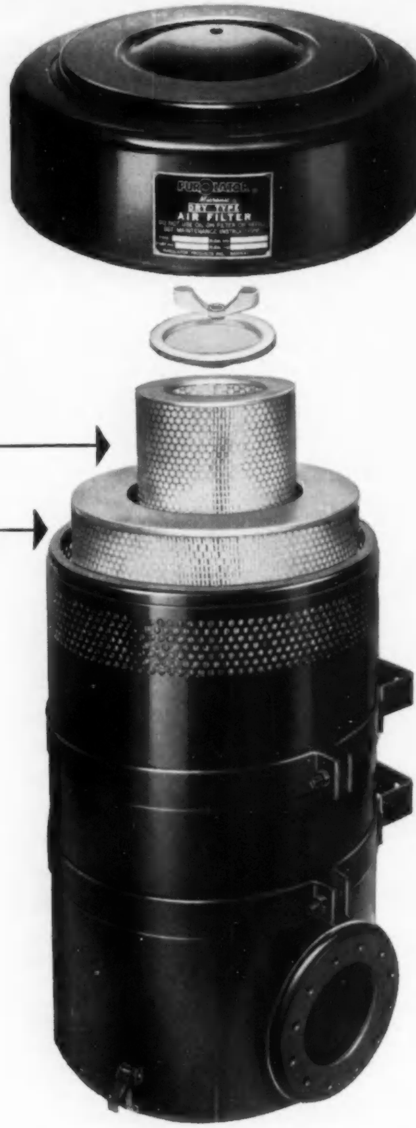
IDLER AT WORK



an element here

and an element here

assures 99.98% filtration efficiency even when 1 element is out of operation



IT'S THE NEW PUROLATOR TWO-STAGE FILTER

Simplicity of design makes the first cost of Purolator's new dry-type two-stage filter as low as any two-stage filter on the market. Each element filters independently, and together they dustproof your engine as no other filter can . . . 99.98% efficient.

Users save money and get better engine protection from this new Purolator filter, too. The first stage element will last up to 2000 hours, depending on operating conditions. The second stage will usually last almost indefinitely if the first element and sealing gaskets are maintained properly.

Another big user-advantage is the way the two-stage design protects the engine despite accidental mishandling of the element. Even if the first stage element is damaged, the chance of harming the engine can be discounted when it is protected with the second stage back stop element. In addition, the second stage element lets the operator service the unit in the field, regardless of how dusty the conditions are.

Both elements filter uniformly, in depth, over their whole surface, because they're both precision made of plastic impregnated cellulose. This series of two-stage filters is rated from 450 to 1150 cfm, with exceptionally low initial restriction. Mounting straps, rainhoods and outlet adapters are available.

For more information write to Purolator Products, Inc., Department 3896, Rahway, New Jersey.

Purolator Products, Inc.
Dept. 3896, Rahway, New Jersey

Please send me complete data on the new Purolator two-stage filter series.

Name ____________________ Title ____________________

Company ____________________

Address ____________________

City ____________________ Zone __________ State __________

Filtration For Every Known Fluid

PUROLATOR
PRODUCTS, INC.
RAHWAY, NEW JERSEY AND TORONTO, CANADA

WEBSTER'S NEW C3F PISTON MOTOR AND PUMP

compact, simple design ■ exceptionally serviceable !

This new hydraulic power unit — developed especially for the machine tool field — features unique application and servicing advantages. Examples: (1) small "package" to fit in close quarters — SAE "A" size mounting can be used with easy access to both mounting holes; (2) simplest axial-type piston pump on the market — fewest parts, fewer potential trouble spots, greater economy; (3) easily serviced — all critical moving parts can be readily replaced in the field. Shaft can be exchanged by disassembling seal end only; (4) unit can be disassembled and the rotation reversed in the field — can be arranged for use as a dual rotation motor; (5) variety of mounting styles — mounting plate and seal assembly is a separate piece and can be furnished in several mounting styles; (6) drive shafts are available with keyways or splines.

The C3F Series can be used as a hydraulic motor (remote rotary locations, screw feeds — anywhere an electric motor might be used) or as a hydraulic pump . . . wherever high torque and smooth, steady force are required. It is available in four sizes — from .72 to 1.81 cubic inches per revolution. Capacities range from 3.3 to 8.5 gpm at 1200 rpm; 7 to 18 gpm at 2400 rpm.

[illegible] adv. H127

C3F SERIES

FIXED DISPLACEMENT AXIAL-TYPE PISTON MOTORS AND PUMPS

Drive: direct, gear or belt

Displacements: four sizes; .72, 1.09, 1.45, 1.81 cu. in. per rev.

Porting: Side ports — horizontal or vertical — handle 1" NPT inlet or 1¼" "O" ring straight thread

Capacity: 3.3 to 8.5 gpm at 1200 rpm
7 to 18 gpm at 2400 rpm

Speeds: to 3000 rpm

Pressures: continuous duty 3000 psi, intermittent rating to 3500

When used as motor:

Torque range (theoretical): four sizes; 11.52, 17.28, 23.04, 28.80 inch pounds per 100 psi

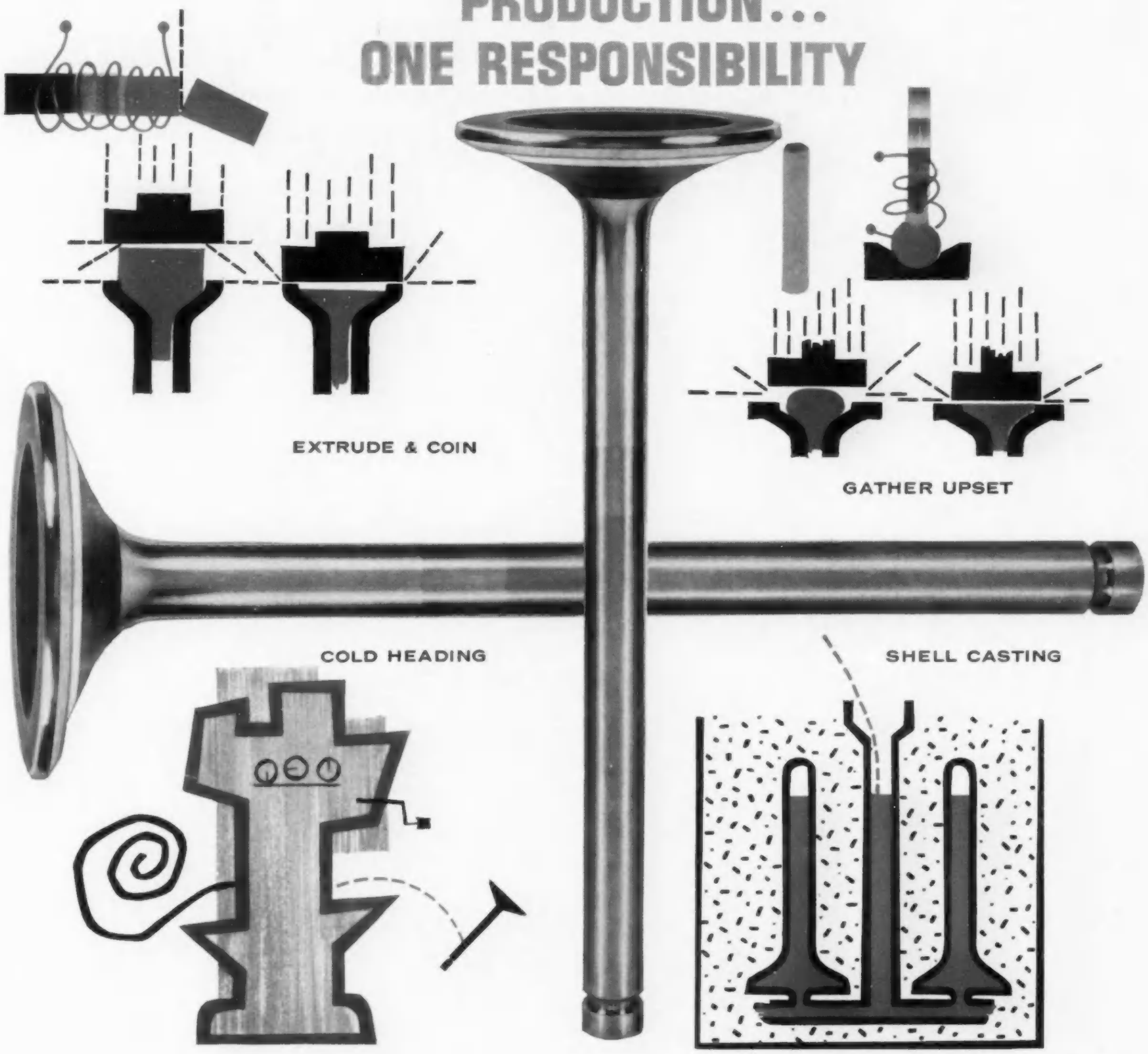
Output: 5.5 to 14 hp. at 3000 psi at 1200 rpm
11 to 28 hp. at 3000 psi at 2400 rpm

OIL HYDRAULICS DIVISION
WEBSTER ELECTRIC
RACINE · WIS

+ INDEX TO ADVERTISERS +

Only the Valve Division offers

4 METHODS OF PRODUCTION... ONE RESPONSIBILITY



The world's largest engine valve plant now supplies valves made by *all four* fabrication methods.

Each method offers its own combination of cost benefits and performance advantages based on your particular engine requirements. All four methods give you the benefits of Thompson's 59 years of leadership in designing and making more than 1.3 billion engine valves.

When you design a new engine or need production valves for current models, come to Thompson's Valve Division . . . where all four valve production methods are used . . . where single responsibility assures quality, delivery, and performance.

THOMPSON PRODUCTS VALVE DIVISION

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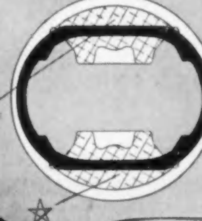
CLEAR-O-MATIC

Controlled Expansion
Cooler Running
Greater Durability

SUPERIOR ENGINEERING DESIGN

The "All-Temperature" Piston
Automatically Maintains Uniform Effective Skirt Clearance at all Temperatures

with these Design Features

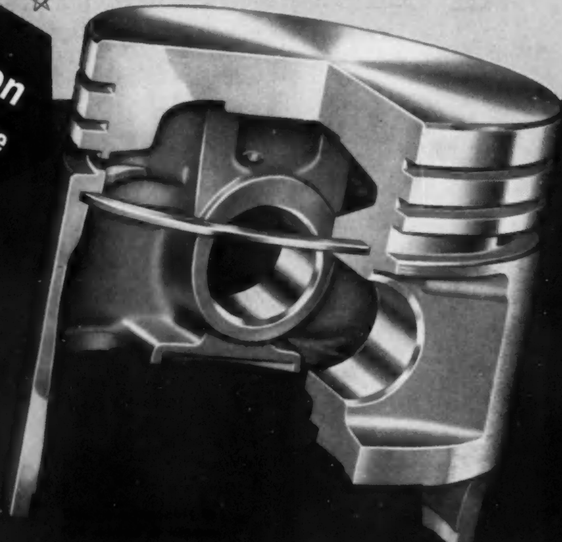


STEEL TENSION MEMBER
Anchored only at pin bosses and cast in positive contact with I. D. of piston skirt.

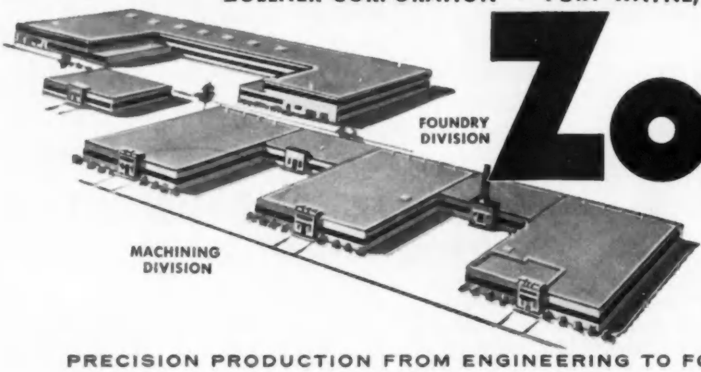
★ **COOLER RUNNING**
20% greater section for heat conductivity.

★ **EXTRA DURABILITY**
Greater section above pin bosses provides uncompromised strength for long life.

For any gasoline engine, performance superiority of the Zollner "Clear-O-Matic" Piston is outstanding. The expertly engineered design of this great piston development incorporates desired advantages in addition to the basic expansion control feature. Clear-O-Matic is a remarkably cool running piston with 20% greater area of conductivity for heat dissipation. This greater section also provides uncompromised strength for long-life durability. Only Clear-O-Matic has all these vital advantages. We suggest an immediate test for your engine.



ZOLLNER CORPORATION • FORT WAYNE, IND.



ZOLLNER
HEAVY DUTY PISTONS

PRECISION PRODUCTION FROM ENGINEERING TO FOUNDRY TO FINISHED PISTONS

Here's where nickel steels give "Payhauler"® extra strength for hustling 27-ton loads

When this beauty roars out of the quarry with 27 tons of rock on its back, you can be sure its gears and shafts encounter brutal shock-loads and torsional stresses.

International Harvester engineers anticipated this rugged service at the design stage, took logical steps to give the "Payhauler" extra stamina:

They specified a variety of vital power-train components in heat-treated nickel alloy steels, case hardened to Rockwell "C" 60 min. for wear resistance, and at the same time providing high core properties for resistance to extreme loads, fatigue and shock.

For transmission gears, and other critical parts that take heaviest impact and compressive stresses, they chose AISI 4817 (3½% Nickel). Made from this steel, gears and pinions handle highest tooth loads, resist spalling, take impact in stride.

For components that meet all but the severest loading and abrasion, the I-H designers selected carburizing grade nickel alloy steels of the AISI 4300 series for the best combination of case and core properties. Carburized AISI 4300 steels (containing 1.85% Nickel) are used for the spiral bevel ring gear, differential pinions and side gears, transmission shafts, and integral axle and sun gear.

When you design, order, or use heavily stressed components of trucks or construction equipment, remember that nickel alloy steels take the tough jobs in stride. The new 76-page booklet, "Nickel Alloy Steels . . . in Engineering Construction Machinery" is packed with valuable engineering information. Write for a free copy. ®Reg. T.M., International Harvester Co.

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NICKEL MAKES STEEL PERFORM BETTER LONGER